NEVF

New England Vegetable & Fruit

CONFERENCE 2013

# New England Vegetable & Fruit

# Conference and Trade Show

## December 17-19, 2013

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## Radisson Hotel Manchester

Manchester, New Hampshire

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# NEVF

## New England Vegetable & Fruit

## CONFERENCE '13

sponsored by the

Cooperative Extension Systems of:

Universities of Connecticut,
Maine, Massachusetts, New Hampshire,
Rhode Island, Vermont,
Cornell University,
Connecticut Agricultural Experiment Station,
Maine Organic Farmers and Gardeners
Association
and
New England Vegetable &
Berry Growers' Association, and
Massachusetts Fruit Growers'
Association

December 17, 18, 19, 2013
Radisson Hotel Manchester

MANCHESTER, NEW HAMPSHIRE

U.S. DEPARTMENT OF AGRICULTURE COOPERATING.

# General Information



## Tuesday Morning Sessions



## Tuesday Afternoon Sessions



## Tuesday Evening Session



## Wednesday Morning Sessions



## Wednesday Afternoon Sessions



## Thursday Morning Sessions



## Thursday Afternoon Sessions

# Greetings and Salutations

Welcome to the 18th New England Vegetable and Fruit Conference and Trade Show. This meeting takes place every other year in December, and includes more than 30 educational sessions over 3 days. Topics include major vegetable, berry and tree fruit crops, and much more.

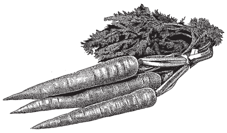
Farmer to Farmer meetings throughout the conference allow you to discuss specific issues in more detail. There is also an extensive Trade Show with over 100 exhibitors. We hope that you will enjoy your time here, and meet with fellow growers, advisors, researchers and industry representatives. We want you to leave with new ideas and information that will have a positive impact on your farm.

This conference is special because it is put together with close collaboration between growers and Extension from across the region. The steering committee gathers the best speakers from within our region and across the country to tell you about the latest innovations and advances in vegetable and fruit production. Almost every session includes both farmers and research or extension personnel, so you are getting the "best of both worlds."

The New England Vegetable and Fruit Extension team also collaborates to conduct research, hold other educational programs, and to create resources for the benefit of growers. These include the New England Vegetable Management Guide, the Small Fruit Pest Management Guide, and the New England Tree Fruit Management Guide which are published every other year. For more information about New England Vegetable and Fruit Extension Programs contact your state Extension offices.

Our sponsors invite you to visit the Trade Show during the conference. We invite businesses and organizations to exhibit at the Trade Show for the purpose of providing information to the participants. While we make responsible efforts to assure the integrity of the exhibitors, the conference sponsors do not guarantee or warranty any product exhibited; neither do the sponsors imply approval of or endorse any product to the exclusion of others that may be available.

We value your feedback! We use your comments and suggestions to plan the next program. Please fill out an evaluation form before you leave!



www.newenglandvfc.org

# 2013 New England Vegetable and Fruit Conference and Trade Show

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**Jude Boucher**

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**Becky Sideman**

*Publicity*
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**Mark Hutton**

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## Steering Committee

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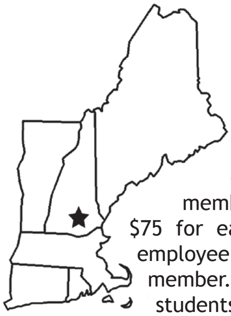
Jiff Martin
Stacia Monahan
William Nail
Skip Paul
Mark Parlee
Howard Prussack
Hilary Sandler
Eric Sideman
Mo Tougas
Jim Ward



## Registration

**Register online at**
newenglandvfc.org

The pre-registration fee to attend any part or all of the conference or trade show is $105 for the first member of the farm or business and $75 for each additional family member or employee when pre-registered with first member. The pre-registration fee for students (high school or college) is $45 each when pre-registered by the instructor.

**Pre-registration must be received by November 30, 2013.** There is an additional fee of $30 per person ($20 students) for late registration or walk-ins. No refunds after 11/30/13.

## Travel to the Conference

Location: Manchester is in the center of New Hampshire, located on US routes 3, I-93 and I-293, and state route 101. It is served by Manchester-Boston Regional Airport.

## Hotel Accommodations

The conference host hotel is the Radisson Hotel in downtown Manchester, NH. Conference attendees are responsible for making their own arrangements for lodging. Rooms have been set aside at special conference rates at both the host hotel and at the Hilton Garden Inn. We encourage you to reserve early, because rooms typically sell out. Hotel reservation and parking information can be found in this brochure.

## Hotel Information

Radisson Hotel – The Center of New Hampshire
700 Elm Street, Manchester, NH
1-603-625-1000
**www.radisson.com/manchesternh**

A limited number of rooms are reserved for conference attendees. The hotel rate for conference attendees is $108 single/double, $118 triple, $128 quad plus tax and parking. NEVF13 is the PAC code that should be used when making reservations on-line or mention you're going to the New England Vegetable & Fruit Conference when making reservations by phone.

Hilton Garden Inn
101 South Commercial Street, Manchester, NH
1-603-669-2222
**www.hiltongardeninn.com**

A limited number of rooms are reserved for conference attendees. The conference rate is $132 per night plus 8% tax. Mention "vegetable conference" to get this rate.

## Parking

Limited parking is available at the host hotel parking garage next to the Radisson hotel. Additionally, a limited number of two hour and ten hour parking meters are available along city streets.

Other parking options:
**Hampshire Plaza Parking Garage**
2 Plaza Drive, Manchester, NH, 03101

**Victory Park Public Garage**
25 Vine Street, Manchester, NH, 03101

## Pesticide Education Credits

Certified pesticide applicators from New England are eligible to receive recertification credit. Growers from New York are NOT eligible to receive pesticide recertification credits. Pick up a form during registration and complete the information on the top portion. Be sure to have your certification number with you. This form is to be used for the entire conference. To get credit for a session, you must attend the entire session and forms must be signed by the Session Moderator at the end of the session. Turn in both the pink and yellow copies of the form at the registration desk when you leave the conference and keep the white copy for your records.

## Certified Crop Advisor: Continuing Education Units

Certified Crop Advisors who attend certain sessions are eligible to receive Continuing Education Units. A sign in/out sheet will be available for each session in the room. CCA members must SIGN IN at the beginning of each session and SIGN OUT at the end of the session. You must attend the entire session to receive credit. Be sure to include your CCA membership number.

## NEVBGA

The New England Vegetable & Berry Growers' Association (NEV & BGA) is the oldest vegetable growers association in America. We support and promote the vegetable and berry industry in New England.

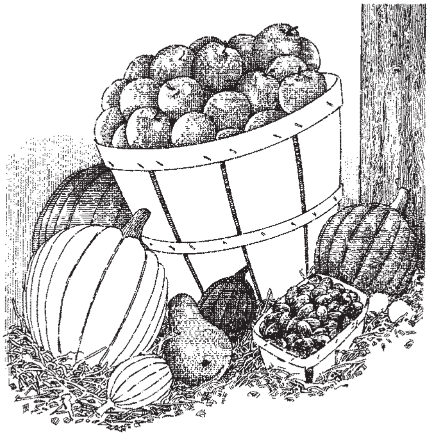
The Association publishes a newsletter three times a year and provides bulletins and magazines deemed important to its members. You are invited to become a member.
Members of the NEV & BGA will be present at an exhibit at the Trade Show. You are encouraged to talk with them about the Association.

## Lunch

Each day of the conference, a soup, salad, and sandwich bar featuring local ingredients will be set up in the foyer outside the Trade Show exhibition hall. In partnership with the Radisson Manchester Downtown, the New England Vegetable and Fruit Conference Steering Committee is pleased to announce the addition of locally grown fruit and vegetables to this year's lunch offerings (also look for items on the menu at JD's Tavern at The Radisson). Local items have been sourced from producers in all six New England states. Many restaurants are also available nearby in downtown Manchester.

## Social Mixer and Awards Program

On **Tuesday** evening, the Trade Show is sponsoring a social from 4:30-6 pm. Light hors d'oevres and non-alcoholic beverages will be provided. On **Wednesday** evening, the Conference is sponsoring a social mixer and awards ceremony from 6 to 7:30 pm with cash bar and light hors-d'oevres. The purpose of this event is to bring everyone together including guests from various state Departments of Agriculture and the New England Land Grant Universities. There will be a short speaking program that will include a brief awards program for the New England Vegetable Berry Growers Association to honor two outstanding contributors for local agriculture. The cost of this event is covered by the Conference and Industry supporters of local agriculture. All are invited to this free event. Dinner will be on your own.



# Farmer to Farmer Sessions and Other Events

**WHAT ARE FARMER-TO-FARMER SESSIONS?**

They are informal "chat" sessions where farmers learn from farmers and other knowledgeable presenters. There will be very short or no presentations at these sessions. Farmers can brainstorm and talk about what works for them and what doesn't, while learning new ideas from all who attend these roundtable discussions.

For each of the topics, bring photos on a stick drive, real photos, your favorite tools, short videos, or anything you have to share with the group.

**WHY SHOULD I ATTEND?**

Much can be learned from a mixed group of farmers, presenters, Extension people, researchers, and other interested folks. It will allow you a chance to ask questions of presenters and also of those who have experience in farming. These sessions have been very popular and successful, so come help and make these sessions a success for everyone again.

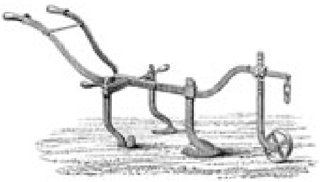
## Tuesday, December 17

12:45 - 1:45 pm **TRACTOR CULTIVATION FOR WEED CONTROL**
Location: BALLROOM A

12:45 - 1:45 pm **ORGANIC FRUIT FROM A TO Z**
Location: CURRIERS

4:30 - 6:00 pm **TRADE SHOW SOCIAL**
Location: EXPO CENTER

4:45 - 5:45 pm **HAND CULTIVATION AND HAND TOOLS: DEMOS, TOOLS ON DISPLAY, MAINTENANCE**
Location: CURRIERS



## Wednesday, December 18

12:00 - 12:45 pm **MASSACHUSETTS FRUIT GROWERS' ASSOCIATION ANNUAL MEETING**
Location: CURRIERS

12:45 - 1:45 pm **THE VALUE OF QUALITY SEEDS: GMO UPDATE, SEED QUALITY, HOT WATER TREATMENT OF SEEDS (WITH DEMO)**
Location: BALLROOM A

12:45 - 1:45 pm **WINTER GROWING/SEASON EXTENSION**
Location: BALLROOM BCD

4:45 - 5:45 pm **NEW AND OLD INSECTS AND ORGANIC CONTROLS**
Location: BALLROOM A

4:45 - 5:45 pm **WASHING STATION TIPS AND TRICKS: SETUPS FOR EFFICIENCY**
Location: CURRIERS

6:00 - 7:30 pm **SOCIAL MIXER AND AWARDS PROGRAM**
Location: BALLROOM BCD

## Thursday, December 19

12:45 - 1:45 pm **ORGANIC DISEASE CONTROL: WHAT'S NEW & WORKS - FROM GREENHOUSE TO FIELD**
Location: BALLROOM A

12:45 - 1:45 pm **IRRIGATION FOR QUALITY CROPS: DRIP, OVERHEAD, FILTRATION**
Location: CURRIERS

## Tuesday, December 17
## Trade Show, 8am - 6pm

### Morning Sessions, 9:30 - 12:00
### Farmer to Farmer, 12:45 - 1:45 & 4:45 - 5:45

## Brambles

LOCATION: CURRIERS
*Moderator: **MARY CONCKLIN***
*Pesticide credits: 1.5, CCA credits: 2.5*

**9:30** **Growing Brambles in High Tunnels**
Marvin Pritts, Cornell University

**10:00** **Irrigation & Fertigation of Brambles**
Trevor Hardy, Brookdale Farm, Hollis NH

**10:30** **Raspberries-by-Color: Quality & Performance in Storage**
Chris Walsh, University of Maryland

**11:00** **Grower Panel: Post-Harvest Handling of Brambles**
Dale-Ila Riggs, The Berry Patch, Stephentown NY
Nate Nourse, Nourse Farms, Whately MA

**11:30** **Key Features of Organic Berry Crop Production**
Marvin Pritts, Cornell University

## Greenhouse Tomato

LOCATION: ARMORY
*Moderator: **ANN HAZELRIGG***
*Pesticide credits: 1.0, CCA credits: 2.5*

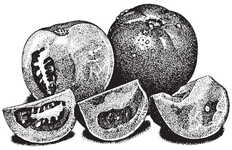
**9:30** **Engineering High Tunnels for Better Performance**
John Bartok, University of Connecticut emeritus

**10:00** **Greenhouse Tomatoes - Start to Finish**
Gideon Porth, Atlas Farm, Deerfield MA

**10:30** **Guardian Plants: The Ultimate Trojan Horse of Pest Management**
Jack Manix, Walker Farm, VT
Margaret Skinner, University of Vermont

**11:00** **Greenhouse Management Techniques for Hoophouse Tomatoes**
Andrew Mefford, One Drop Farm, Cornville ME and Johnny's Selected Seeds

**11:30** **Heating and Cooling Alternatives Can Improve High Tunnel Tomato Production**
John Bartok, University of Connecticut emeritus



## Mechanical Weed Control

LOCATION: BALLROOM BCD
*Moderator: **VERN GRUBINGER***
*Pesticide credits: 2.5, CCA credits: 2.5*

**9:30** **A Whole Farm Approach to Weed Management**
Jean-Paul Courtens, Roxbury Farm, Kinderhook NY

**10:00** **Timing Cultivations for Maximum Weed Control**
Eric Gallandt, University of Maine

**10:30** **Cultivating with a Farm-Fabricated Steerable Cultivator**
Ted Blomgren, Windflower Farm, Vallery Falls NY

**11:00** **Making the Most of Tine Weeders**
Klaas Martens, Martens Farm, Penn Yan NY

**11:30** **Pros & Cons of Cultivation Equipment for New Farmers**
Sara Runkel, Great Bend Farm, Port Clinton PA

## Specialty Fruit

LOCATION: FROST/HAWTHORNE (UPSTAIRS)
*Moderator: **HILARY SANDLER***
*Pesticide credits: 1.5, CCA credits: 2.0*

**9:30** **Greenhouse-grown Figs: How to Survive the Winter Chill**
Skip Paul, Wishing Stone Farm, Little Compton RI

**10:00** **Pawpaw, a Hardy Fruit with Tropical Aspirations**
Lee Reich, New Paltz, NY

**10:30** **Why Cranberries? Growing and Marketing Cranberries in Non-traditional Areas, Using Low-input**
Bob Lesnikoski, Vermont Cranberry Company, E. Fairfield VT

**11:00** **BOGS Online Grower System, A Record Keeping and Pest Management Decision Tool**
Brian Wick, Cape Cod Cranberry Growers' Association

**11:30** **Hardy Kiwifruit, Better than the Fuzzies**
Lee Reich, New Paltz, NY

## Sweet Corn

LOCATION: BALLROOM A
*Moderator: **JUDE BOUCHER***
*Pesticide credits: 2.0, CCA credits: 2.5*

**9:30** **Effects of Plant Density and Tillage on 'Montauk' Sweet Corn Ear Size and Profits**
Robert Durgy, Connecticut Agricultural Experiment Station

**10:00** **Western Bean Cutworm: A New Corn Ear Pest in NE**
Andrew Michel, The Ohio State University

**10:30** **Managing Northern Corn Leaf Blight: An Emerging Disease in New England**
Robert Wick, University of Massachussetts

**11:00** **To be determined**

**11:30** **Air Blast Sprayers for Sweet Corn - Calibration & Adjustment**
George Hamilton, University of New Hampshire Extension

## Tuesday, December 17
## Trade Show, 8am - 6pm

### Afternoon Sessions, 2:00 - 4:30
### Farmer to Farmer, 12:45 - 1:45 & 4:45 - 5:45

### Tomatoes

LOCATION: BALLROOM BCD

*Moderator:* ***BECKY SIDEMAN***
*Pesticide credits: 2.5, CCA credits: 2.5*

**2:00** **Update on Late Blight Management: Can Resistant Varieties Play a Role?**
Meg McGrath, Cornell University Cooperative Extension

**2:30** **Panel Discussion: Tomato Varieties that Taste Good, Grow Well and Sell!**
Amy LeBlanc, Whitehill Farm, East Wilton ME
Heather Bryant, University of New Hampshire Extension
Jim Ward, Ward's Berry Farm, Sharon MA

**3:30** **Designing an Effective Fungicide Program (organic and conventional) to Manage Tomato Diseases**
Meg McGrath, Cornell University Cooperative Extension

**4:00** **Grafted Plants in the Field: When they Make the Most Sense**
Matthew Kleinhenz, Ohio State University

### Direct Marketing & Technology

LOCATION: BALLROOM A

*Moderator:* ***TORI LEE JACKSON***

**2:00** **Market Mobile and Farm-to-Table Operations**
Jesse Rye, Farm Fresh Rhode Island, Pawtucket RI

**2:45** **Social Media, Web & Email Marketing at Kilpatrick Family Farm**
Michael Kilpatrick, Kilpatrick Family Farm, Middle Granville NY

**3:30** **Online Buying Clubs**
Sarah Miller, Long Branch Online Buying Club, Bowdoinham ME

**4:00** **To be determined**

### Many Facets of CSA Management

LOCATION: FROST/HAWTHORNE (UPSTAIRS)

*Moderator:* ***VERN GRUBINGER***
*CCA credits: 2.5*

**2:00** **Lessons Learned Offering Summer, Fall & Winter Shares**
Christa Alexander, Jericho Settlers Farm, Jericho VT

**2:30** **Managing a Large-Scale CSA with Mulitple Locations**
Ryan Voiland, Red Fire Farm, Granby MA

**3:00** **Keys to Success with Workplace CSAs**
Tom Harms, Wolf Pine Farm, Alfred ME

**3:30** **A Decade of Experience with a Multi-Farm CSA**
David Trumble, Good Earth Farm, Weare NH

**4:00** **Recruiting and Retaining CSA Members**
Stacia Monahan, Stone Gardens CSA, Shelton CT

**4:30** **Farm to Kitchen: A Vertically Integrated CSA**
Joe Buley, Screamin' Ridge Farm, Montpelier VT

## Stone Fruit

LOCATION: CURRIERS
*Moderator: **DUANE GREENE***
*Pesticide credits: 2.0*

**2:00** **Description of an IPM Program for Peaches**
Mary Concklin, University of Connecticut

**2:30** **Update on Peach Pruning**
Jim Schupp, Pennsylvania State University

**3:00** **A 40-year Perspective of Research on Tree Fruit Diseases**
David Rosenberger, Cornell University

**3:30** **Peach Training Systems**
Jim Schupp, Pennsylvania State University

**4:00** **Simple Rules: Mechanization for Higher Labor Efficiency**
Mario Miranda Sazo, Cornell Cooperative Extension

## Winter Growing

LOCATION: ARMORY
*Moderator: **ANDY RADIN***
*Pesticide credits: 1.5, CCA credits: 2.5*

**2:00** **Profitable Production of Quality Winter Greens in Unheated NY High Tunnels**
Paul Arnold, Pleasant Valley Farm, Argyle NY

**2:30** **Bed Preparation and Seeding Technique**
Andre Cantelmo, Heron Pond Farm, South Hampton NH

**3:00** **Greens Production with Ground Heat**
Seth Jacobs, Slack Hollow Farm, Argyle, NY

**3:30** **Growing for Retail Markets in S. New England with Field, Low Tunnel and High Tunnel Production**
Skip Paul, Wishing Stone Farm, Little Compton RI

**4:00** **Winter Production with Movable Tunnels**
Nate Drummond, Six River Farm, Bowdoinham ME

# Evening Session, 5:00 - 7:30

## Spotted Wing Drosophila

LOCATION: BALLROOM ABCD
*Moderator: **MARY CONCKLIN***
*Pesticide credits: 2.5, CCA credits: 2.5*

**5:00** **SWD IPM: Are We There Yet?**
Richard Cowles, Connecticut Ag. Experiment Station

**5:30** **Panel Discussion: Experiences From the Field**
Dale-Ila Riggs, The Berry Patch, Stephentown NY
Nate Nourse, Nourse Farms, Whately MA
Mike Libby, Libby & Son U-Picks , Limerick ME

**6:00** **SWD Management in Berry Crops: Lessons from the Michigan Experience**
Rufus Isaacs, Michigan State University

**6:30** **'Outside the Box' Options for SWD Management**
Peter Jentsch, Cornell University

**7:00** **SWD Trapping Out Experiences**
Dave Handley, University of Maine Extension
Heather Faubert, University of Rhode Island
Mary Concklin, University of Connecticut

## Wednesday, December 18
## Trade Show, 8am - 6pm

### Morning Sessions, 9:30 - 12:00
### Farmer to Farmer, 12:45 - 1:45 & 4:45 - 5:45

### Blueberry I

LOCATION: FROST/HAWTHORNE (UPSTAIRS)
*Moderator: **DAVID HANDLEY***
*Pesticide credits: 2.5, CCA credits: 2*

**9:30** **Are Blueberries for You?**
David Handley, University of Maine Extension

**10:00** **Variety Update**
Eric Hanson, University of Michigan

**10:30** **Pruning: How and Why**
Gary Pavlis, Rutgers University

**11:00** **Insect ID 101**
Heather Faubert, University of Rhode Island

**11:30** **Blueberry Virus Issues**
Frank Caruso, University of Masschusetts emeritus

### Greenhouse & Tunnel Technical Tips

LOCATION: ARMORY
*Moderator: **VERN GRUBINGER***
*CCA credits: 2.5*

**9:30** **Design and Construction of Greenhouses and Tunnels**
Ed Person, Ledgewood Farm Greenhouses, Moultonborough NH

**10:00** **Update on Plastic, Polycarbonate, Acrylic and Glass Coverings**
John Bartok, University of Connecticut emeritus

**10:30** **Automation to Save Labor in the Greenhouse**
Jack Manix, Walker Farm, Dummerston, VT

**11:00** **Micro-Irrigation Options for Greenhouses and Tunnels**
Trevor Hardy, Brookdale Farm, Hollis NH

**11:30** **Heating a Greenhouse with Wood Pellets and Corn**
Andy Jones, Intervale Community Farm, Burlington VT

### Organic

LOCATION: BALLROOM BCD
*Moderator: **ERIC SIDEMAN***
*Pesticide credits: 1.5, CCA credits: 1.5*

**9:30** **Emerging New Pests and New Copper Fungicides**
Eric Sideman, Maine Organic Farmers & Gardeners Association
Meg McGrath, Cornell University Cooperative Extension

**10:00** **Nutrient Management in Organic Cropping Systems**
John Spargo, University of Massachussetts

**10:30** **Contrasting Soil Management in High Tunnels Versus Field Production**
Rhonda Janke, Kansas State University

**11:00** **An Over View of Our Farm, with Details on Soil and Pest Management**
Nate Drummond, Six River Farm, Bowdoinham ME

**11:30** **An Over View of Our Farm, with Details on Soil and Pest Management**
Jake Guest, Kildeer Farm, Norwich VT

## Root Crops

LOCATION: BALLROOM A
*Moderator: **BECKY SIDEMAN***
*Pesticide credits: 2.0, CCA credits: 2.5*

**9:30** **Postharvest Handling of Garlic for Successful Storage**
Crystal Stewart, Cornell University Cooperative Extension

**10:00** **Carrots for Winter Sales: Varieties, Planting Dates and Post-harvest Care**
Amanda Brown, University of Massachusetts

**10:30** **Overwintering Onions for Early Spring Market**
Becky Sideman, University of New Hampshire Extension

**11:00** **Potatoes: Producing High Quality Seed and Table Stock**
Bob Chappelle,Chappelle's Vermont Potatoes, Williamstown VT

**11:30** **Terror Underground: Why Wireworms Are So Hard to Control**
Andrei Alyokhin, University of Maine

## Tree Fruit I

LOCATION: CURRIERS
*Moderator: **DUANE GREENE***
*Pesticide credits: 1.5, CCA credits: 2.0*

**9:30** **Getting Started in Hard Cider Production: A Growers Perspective**
Peter Mitchell, Headwater Cider Company, Hawley MA

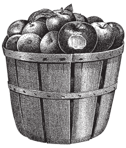
**10:00** **Common Mistakes to Avoid When Planting, Establishing and Training Spindle Apple Trees**
Mario Miranda Sazo, Cornell Cooperative Extension

**10:30** **Keys to Successfully Growing Honeycrisp in Nova Scotia**
Larry Lutz, Scotian Gold Cooperative, Berwick Canada

**11:00** **Practical Suggestions for Effective Pollination with Bees**
Tim Smith, Apex Orchard, Shelburne MA

**11:30** **Native and Invasive Stink Bug Management**
Peter Jentsch, Cornell University

## Massachusetts Fruit Growers' Association Annual Meeting, 12:00 - 12:45



## Wednesday, December 14
## Trade Show, 8am - 6pm

### Afternoon Sessions, 2:00 - 4:30
### Farmer to Farmer, 12:45 - 1:45 & 4:45 - 5:45

### Blueberry II

LOCATION: BALLROOM A

*Moderator:* ***DAVID HANDLEY***

*Pesticide credits: 2.0, CCA credits: 2.0*

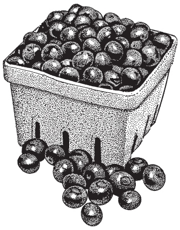
**2:00** **Blueberry Nutrition**
Eric Hanson, University of Michigan

**2:30** **Managing Harvest and Postharvest Fruit Quality**
Gary Pavlis, Rutgers University

**3:00** **Blueberry Root Rot Issues**
Frank Caruso, University of Massachusetts

**3:30** **Blueberry Maggot Update**
Alan Eaton, University of New Hampshire Extension

**4:00** **Blueberries at Libby & Son U-Pick**
Aaron Libby, Libby & Son Orchard, Limerick ME



### Cut Flowers

LOCATION: FROST/HAWTHORNE (UPSTAIRS)

*Moderator:* ***HEATHER FAUBERT***

*Pesticide credits: 1.0, CCA credits: 2.5*

**2:00** **Keeping the High Tunnel Full of Cuts Year-round**
Chris Wien, Cornell University

**2:30** **Starting a Flower Farm**
Michael Wells, 365 Fresh & Harris Seed, Rochester NY

**3:00** **Techniques to Maximize Production of Sunflowers, Larkspur and Delphinium**
Chris Wien, Cornell University

**3:30** **Taking Cut Flowers from Sideshow to Main Event: The Tipping Points of Growing Our Flower Business**
Carolyn Snell, Snell Family Farm, Buxton ME

**4:00** **Cutting & Caring; Post-harvest Handling**
Polly & Mike Hutchinson, Robin Hollow Farm, Saunderstown RI

## Optimizing Storage Crop Quality

LOCATION: BALLROOM BCD

*Moderator: **VERN GRUBINGER***
*Pesticide credits: 1.0, CCA credits: 2.5*

**2:00** **Designing a Good Storage System: An Engineer's Perspective**
Chris Callahan, University of Vermont Extension

**2:30** **Putting a Good Quality Crop into Storage**
Jan van der Heide, Bejo Seeds, Geneva, NY

**3:00** **Underground Passive Storage for Root Crops at Brookfield Farm**
Dan Kaplan, Brookfield Farm, Amherst MA

**3:30** **Maintaining Storage Crop Quality at Pleasant Valley Farm**
Paul Arnold, Pleasant Valley Farm, Argyle NY

**4:00** **From Field to Storage: High Quality Carrots**
Ruth Hazzard, University of Massachusetts Extension

## Soil Health

LOCATION: ARMORY

*Moderator: **MARK HUTCHINSON***
*Pesticide credits: 1.5, CCA credits: 2.5*

**2:00** **Soil Management in High Tunnel Vegetable Production: Emphasizing Long-term Success**
Matthew Kleinhenz, Ohio State University

**2:30** **Using Cover Crops in High Tunnels**
Paul Volckhausen, Happy Town Farm, Orland ME

**3:00** **Soil Management and Soil Quality in High Tunnel Production Systems**
Rhonda Janke, Kansas State University

**3:30** **Soil and Fertility Practices in Passive Solar High Tunnel for Winter and Summer Crops**
Joe Buley, Screamin' Ridge Farm, Montpelier VT

**4:00** **Soil Testing Options for High Tunnel Production**
Bruce Hoskins, University of Maine

## Tree Fruit II

LOCATION: CURRIERS

*Moderator: **DUANE GREENE***
*Pesticide credits: 2.5, CCA credits: 2.5*

**2:00** **Proper Sprayer Calibration**
George Hamilton, University of New Hampshire Extension

**2:30** **Lepidopteran Resistance Pest Management Strategies**
Peter Jentsch, Cornell University

**3:00** **Fungicide Selection to Minimize Resistance Development**
David Rosenberger, Cornell University

**3:30** **Implementation of Precision Thinning in New York**
Mario Miranda Sazo, Cornell Cooperative Extension

**4:00** **Building the Perfect Orchard- Experiences with Orchard Establishment in Nova Scotia**
Larry Lutz, Scotian Gold Cooperative, Berwick Canada

## Thursday, December 19
## Trade Show, 8am - 2pm

### Morning Sessions, 9:30 - 12:00
### Farmer to Farmer, 12:45 - 1:45

## Cucurbits

LOCATION: BALLROOM A

*Moderator: **AMY OUELLETTE***
*Pesticide credits: 2.0, CCA credits: 2.5*

**9:30** **Prevention and Management of Viruses in Cucurbit Crops**
Marc Fuchs, Cornell University

**10:00** **Reduced Tillage Techniques in Cucurbit Crops**
Jim Ward, Ward's Berry Farm, Sharon MA

**10:30** **Monitoring for Squash Vine Borer in New Hampshire**
George Hamilton, University of New Hampshire Extension

**11:00** **Disease Management of Cucurbit Crops**
Meg McGrath, Cornell University Cooperative Extension

**11:30** **The Nuts and Bolts of Fruit Quality in Cucurbits**
Brent Loy, University of New Hampshire

## From Greenhouse to Field (Transplants)

LOCATION: CURRIERS

*Moderator: **SANDY ARNOLD***
*Pesticide credits: 1.5, CCA credits: 2.5*

**9:30** **Extensive Soil Mix Studies for Greenhouse Production of Seedlings and Transplants**
Neil Mattson, Cornell University Cooperative Extension

**10:00** **From Greenhouse to Field with Quality Transplants**
Dave Hambleton, Sisters Hill Farm, Stanfordville, NY

**10:30** **Greenhouse Transplants through Quality Seeds and Controlling Diseases**
Meg McGrath, Cornell University Cooperative Extension

**11:00** **Transplants for Profit**
Jason Kafka, Checkerberry Farm, Parkman ME

**11:30** **What Makes a Great Transplant: How To Achieve It & Mistakes to Avoid**
Jan van der Heide, Bejo Seeds, Geneva, NY

## Strawberry I

LOCATION: BALLROOM BCD

*Moderator: **SONIA SCHLOEMANN***
*Pesticide credits: 2.0, CCA credits: 2.0*

**9:30** **Strawberry Planting Basics at 4 Corners Farm**
Bob Gray, Four Corners Farm, Newbury VT

**10:00** **Varieties – Tried and True/ New and Promising**
Courtney Weber, Cornell University/NY Agriculture Experiment Station

**10:30** **Insect and Disease – What to be Ready for and IPM Practices**
Sonia Schloemann, University of Massachusetts Extension

**11:00** **Weed Management and other Cultural Practices**
David Handley, University of Maine Extension

**11:30** **Annual Production System- how it works for us**
Michael Kilpatrick, Kilpatrick Family Farm, Middle Granville NY

## Sweetpotatoes

LOCATION: ARMORY

*Moderator: **BECKY SIDEMAN***
*Pesticide credits: 2.0, CCA credits: 1.5*

**9:30** **Tips from the Sweetpotato Experts: Sweetpotato Production in North Carolina**
Jonathan Schultheis, North Carolina State University

**10:30** **Varieties, Cultural Practices, and Post-harvest Management for New England**
Becky Sideman, University of New Hampshire Extension
Chuck Bornt, Cornell University Cooperative Extension

**11:00** **Our Experiences Growing Organic Sweetpotatoes**
Dan Landis, Landisdale Farms, Jonestown PA

**11:30** **Our Experiences Growing Organic Sweetpotatoes**
Justin Rich, Burnt Rock Farm, Huntington VT

## Viticulture I

LOCATION: FROST/HAWTHORNE (UPSTAIRS)

*Moderator: **WILLIAM NAIL***
*Pesticide credits: 1.5, CCA credits: 2.0*

**9:30** **Introduction to Grape Growing**
Paolo Sabbatini, Michigan State University

**10:10** **Cultivar Selection**
Mark Chien, Pennsylvania State University

**10:50** **Recent Advances in Vineyard Sprayer Technology**
Andrew Landers, Cornell University

**11:30** **Site Selection and Vineyard Design**
Mark Chien, Pennsylvania State University

## Thursday, December 19
## Trade Show, 8am - 2pm

## Afternoon Sessions, 2:00 - 4:30
### Farmer to Farmer, 12:45 - 1:45

### Brassica and Leafy Greens

LOCATION: ARMORY

*Moderator*: ***SANDY ARNOLD***
*Pesticide credits: 2.0, CCA credits: 2.5*

**2:00** **Brussels Sprout Trials for Variety, Spacing, Topping, Mulching and Disease Control**
Andre Cantelmo, Heron Pond Farm, South Hampton NH

**2:30** **Brassica Production in Rhode Island**
Skip Paul, Wishing Stone Farm, Little Compton RI

**3:00** **Insect and Disease Control on Brassicas**
Ruth Hazzard, University of Massachusetts Extension

**3:30** **Strategies for Continuous Production of Summer Salad Greens/Leafy Greens**
Dave Colson, Maine Organic Farmers & Gardeners Association

**4:00** **Profitable Greens through Culitivation & Healthy Soils on a Small Farm**
Seth Jacobs, Slack Hollow Farm, Argyle, NY

### Making Farm Decisions

LOCATION: CURRIERS

*Moderator*: ***CHUCK BORNT***
*Pesticide credits: 1.0*

**2:00** **Stay Small & Turn Up the Awesome!: Making A Living on 2 Acres in Burlington, VT**
Mara and Spencer Welton, Half Pint Farm, Burlington VT

**2:30** **Tools and Techniques for Transitioning from Small to Large Scale Produciton**
Christa Alexander, Jericho Settlers Farm, Jericho VT

**3:00** **How We Make Decisions on Kilpatrick Family Farm**
Michael Kilpatrick, Kilpatrick Family Farm, Middle Granville NY

**3:30** **Technology and Methods to Making Scaling Up Profitable and Labor Efficient**
Adam Hainer, Juniper Hill Farm, Wadhams NY

**4:00** **Want to Borrow Money - What Financers are Looking For When Lending Money**
Dorothy Suput, The Carrot Project, Somerville MA

### Pumpkins

LOCATION: BALLROOM A

*Moderator*: ***GEORGE HAMILTON***
*Pesticide credits: 1.5, CCA credits: 1.5*

2:00 **Producing Exotic Types of Pumpkins and Ornamental Squashes**
Mac Condill, The Great Pumpkin Patch and The Homestead Seeds, Arthur IL

**2:30** **New Innovations in Pumpkins**
Brent Loy, University of New Hampshire

**3:00** **Effects of Fungicide Timing and Tillage on Powdery Mildew-Resistant Pumpkins**
Jude Boucher, University of Connecticut Extension

**3:30** **Marketing Pumpkins and Ornamental Squash at The Great Pumpkin Patch**
Mac Condill, The Great Pumpkin Patch and The Homestead Seeds, Arthur IL

**4:00** **We Make Pumpkins Fly Through The Air - Ag-Entertainment!**
Brian Labrie, Team American Chunker (Air Cannon)
Steve Seigars, Yankee Siege (Trebuchet)

## Strawberry II

LOCATION: BALLROOM BCD

*Moderator:* ***SONIA SCHLOEMANN***
*Pesticide credits: 1.0, CCA credits: 2.5*

**2:00** **Strawberry Crop Nutrition**
Laura McDermott, Cornell Cooperative Extension

**2:35** **Dayneutral Strawberry Production in the Northeast**
Dale-Ila Riggs, The Berry Patch, Stephentown NY

**3:05** **Frost Protection Strategies for Strawberries**
Mary Concklin, University of Connecticut

**3:45** **Sprayer Calibration**
George Hamilton, University of New Hampshire Extension

## Viticulture II

LOCATION: FROST/HAWTHORNE (UPSTAIRS)

*Moderator:* ***WILLIAM NAIL***
*Pesticide credits: 1.5, CCA credits: 2*

**2:00** **SWD in Grapes: How Much of a Problem?**
Richard Cowles, Connecticut Agricultural Experiment Station

**2:40** **Table Grapes for New England**
Tim Smith, Tim Smith Consulting

**3:20** **Vine Balance- What Is It and How Do We Achieve It?**
Paolo Sabbatini, Michigan State University

**4:00** **Jack Frost Nipping and Your Nodes: Grapevine Cold Hardiness and Strategies to Handle Winter Cold**
Terry Bradshaw, University of Vermont

# Trade Show Exhibitors

Adams County Nursery
AeroCoir
Applied Ag Tech
Arthur Carroll Crop Insurance
Arysta Life Sciences
Atlantic Power Solutions, Inc
N. M. Bartlett, Inc.
BASF Corporation
Bayer Crop Science
BDi Machinery Sales, Inc.
Belle Terre Irrigation, LLC
BioSafe Systems
Brookdale Fruit Farm Irrigation
Caro Vail
Casella Organics
Country Folks Grower
Crop Production Services
Csi-Nutri-Cal
Decco US Post-Harvest, Inc.
Delta T Solutions
Devon Lane Farm Supply
Dow Agro Sciences
Dubois Agrinovation
East Branch Ginger
Empire Packaging
Farm Aid
Farm Credit East, ACA
Gowan
Griffin Greenhouse Supplies
Crop Care
Growth Products LTD
Harnois Greenhouses
Harris Seeds
Haygrove Tunnels
Helena
High Mowing Seeds
Hillside Cultivator
Independent Ag Equipment
Johnny's Selected Seeds
Jolly Farmer
Kreher Enterprise
Kube Pak Corp.
Maple Ridge Supply
Mankar Ultra Low Volume Sprayers
Mechanical Transplanter Co.
Miller Chemical & Fertilizer Corp.
Monte Packge Company
Moose River Media/Growing Magazine
MANA
Nachurs Alpine Soulutions
New England Seed Co.
New Hampshire & Massachusetts Farm Bureau
O. A. Newton Irrigation
North Country Organics
Northeast Nursery, Inc.
Nourse Farms, Inc.
Novozymes BioAg, Inc.
Nufarm Americas
OESCO
PCA Supply Services
Recoltech Mkt Garden Accessories
Rimol Greenhouse Systems
River Valley Fencing
Rockford Packaging
Seedway
Spec Trellising
Spectrum Technologies
Stokes Seeds, Inc.
Summit Tree Sales
Suntex CP, Inc.
Syngenta Crop Protection
Tew Manufacturing Corp.
The Carrot Project
The Chas. C Hart Seed Co.
Treen Box and Pallet
US Dept of Labor
Valent U. S. A
Vermont Compost Co.
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Wafler Nursery
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NEVF

New England Vegetable & Fruit

CONFERENCE 2013

# New England Vegetable & Fruit Conference and Trade Show

December 17-19, 2013

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Radisson Hotel Manchester

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# NEVF

## New England Vegetable & Fruit

## CONFERENCE 2013

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and
Massachusetts Fruit Growers' Association

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**December 17, 18, 19, 2013**

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**Growing Brambles in High Tunnels**

Marvin Pritts
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Raspberries and blackberries rank among the high-value crops such as tomatoes, cucumbers and greens that have been successfully grown in high tunnels in northern climates. High tunnels are known to protect plants from cold temperatures, but with very perishable and sensitive berry crops, high tunnels also provide protection against wind, rain and dew. The quality of berries from tunnels far exceeds that from the open field, and yield differences can be dramatic. For example, blackberries have a difficult time surviving winters in the open. In high tunnels, however, survival can be 100% and yields can approach 40,000 lbs per planted acre. With fall raspberries, the season can be extended from 4 weeks to 10 weeks or longer, with yields exceeding those of the open field by several-fold. Economic analyses indicate that all start-up costs can be paid for after 5 years, which is remarkable for an agricultural enterprise.

In our experience, the bramble crops most responsive to high tunnels are summer blackberries, fall red raspberries, and fall blackberries. Benefits accrue to summer red raspberries and black raspberries as well, but the differences between open field and tunnels are smaller. New cultivars of fall-fruiting blackberries adapted to high tunnels in the Northeast are just now being developed, so there are not yet any that are suitable at this time. Therefore, the presentation will only consider summer blackberries and fall raspberries.

The tunnel environment favors high fruit quality, fewer diseases and better plant growth resulting in higher yields. But the main purpose of the tunnel is different for the two types. For blackberries, the tunnel allows the plants to overwinter in our harsh climate where they otherwise would die or be significantly damaged. For this reason, the tunnel has to be "four-seasons" and able to withstand snow loads in winter. This requires more durable construction. For fall raspberries, the main purpose is to extend the harvest season into fall. After the last harvest, the plastic can be removed (it is even desirable to do so). Since the tunnel will not have to withstand a snow load, a less durable tunnel is required. Regardless, the tunnels must accommodate growth that exceeds that which is observed in the field. Therefore, wide (30 ft) and tall (14 ft or higher with 4 ft sidewalls) tunnels are best.

Many details are involved with the construction, planting, training, harvest and pest management of tunneled brambles. Readers are encouraged to download our 50-page publication http://fruit.cornell.edu/berry/production/pdfs/hightunnelsrasp2012.pdf entitled "High Tunnel raspberries and Blackberries" for those details.

**Selection Efficiency for Postharvest Shelf Life Affected by Storage Temperature and Harvest Season for Raspberry Fruit**

Julia M. Harshman[1], Kim S. Lewers[2], Wayne M. Jurick II[3], Christopher S. Walsh[1]
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[2]Genetic Improvement of Fruits and Vegetables Laboratory, United States Department of Agriculture, Agricultural Research Service, 10300 Baltimore Ave., Building 010A, Beltsville, MD 20705 USA
[3]Food Quality Laboratory, United States Department of Agriculture, Agricultural Research Service, 10300 Baltimore Ave., Building 002, Beltsville, MD 20705 USA

As growers capitalize on novelty fruit crops and consumers are told to eat a more colorful diet, different colored raspberries are a growing interest. Increasing the colors of raspberries in the market can benefit both consumers and producers. Red raspberries are the most commonly consumed raspberry, and therefore the most information is known about how this fruit crop performs after harvest. Considerably less information is known about the quality and storability of purple, black and yellow raspberries.

Using an existing planting in Beltsville, Maryland, we developed a postharvest research program to study postharvest pathology and physiology of this perishable fruit crop. Plants were trellised, pruned for double-cropping and treated with herbicides. Since many eastern raspberry growers prefer low-input or organic production of this crop, we chose not to make any insecticide or fungicide applications to this research planting.

The floricane (spring) and primocane (fall) fruits were harvested during two consecutive years. Fruits were picked at commercial maturity directly into CoStar® plates to assess fruit bleed and rot. Larger samples were taken for measurements of firmness, soluble solids content, titratable acidity, anthocyanins and other measures of reactive oxygen species.

Since relatively little postharvest work has been conducted on this crop, we also measured ethylene evolution and respiration rates in selected cultivars. These were harvested and disinfected using alcohol to reduce spoilage and placed in a flow-through system to measure ethylene and respiration rates using a gas chromatograph.

In our study, red raspberries had the lowest ratio of soluble solids to titratable acidity which determines the raspberry flavor expected by consumers. They also had lower anthocyanin and phenolic content levels than either black or purple raspberries. They were intermediate in firmness at harvest but tended to bleed during storage. Red raspberries harvested after overcast rainy days and a humid night bled more. Red fruit rotted more rapidly (Fig 1), especially when harvested after hot, humid days. Red cultivars also produced the most ethylene during ripening.

Yellow raspberries had the lowest levels of anthocyanins and phenolics. Their titratable acidity was lower than red raspberries but their ratio of soluble solids to titratable acidity was closest to those of red raspberry fruit. This bodes well for their consumer acceptance as this is an important indicator of flavor. Yellow raspberries resisted bleeding the best (Fig 1), although they bled more quickly when harvested on overcast days. Yellows were the firmest at harvest but were very susceptible to grey mold, especially after being harvested on overcast, cool, humid days. Their ethylene and respiration rates were similar to red raspberries.

Fresh black raspberries are an increasing presence in local markets, and are very attractive to consumers for their perceived health benefits. Their flavor was less tart than red raspberries, as they had the lowest titratable acidity and highest (best) sugar to acid ratio. Black raspberries were the most susceptible to bleeding which makes their handling in the wholesale, fresh market a challenge. On the other hand, they were the firmest at harvest and also the most decay resistant fruits in this study. Black raspberries also had the lowest ethylene and $CO_2$ evolution rates, which may indicate why they were the most resistant to decay.

Purple raspberries, which are a hybrid between red and black raspberries, are popular in the northeastern US. They had the third highest anthocyanin and phenolic content, and their flavor was intermediate between black and yellow raspberries. Like black raspberries, their ability to resist bleed was poor (Fig 1). Cool weather tended to exacerbate this problem. While purple fruit were not as firm as black raspberries, they resisted decay well. Humid days before harvest lowered their decay resistance. Their ethylene and $CO_2$ evolution rates were intermediate between red raspberries and black raspberries which also corresponded with their ability to resist decay.

Phenolic content coupled with low ethylene evolution rates may help explain the low susceptibility of decay for purple raspberries despite a lack of firmness at harvest and rapid bleed postharvest. High total phenolic content has been shown to have antifungal effects in other plant species. A study to determine to test whether total phenolics actually act *in vivo* to reduce decay is needed.

Data from our study also supports the claim that raspberries are not a classical climacteric fruit. They did not have a corresponding increase in $CO_2$ output coinciding with their increase in ethylene evolution. However, we have shown for the first time that differences between ethylene rates and decay incidence coincide. Berry species and cultivars with the greatest ethylene evolution rates rotted the most rapidly.

It is unclear if the ethylene we measured was liberated by the fungus, produced by the fruit, or by both. Since it has been shown that ethylene is a ripening hormone that promotes senescence and that *B. cinerea* has the ability to sense and respond to exogenous ethylene, it is logical to assume that ethylene is involved in the host-parasite interaction. Our findings have great impact as they open the door for potential disease mitigation strategies that center around lowering ethylene emission rates on berries to reduce decay. Plant breeders can also use this information to screen raspberry germplasm to look for low ethylene liberating berries to use as material for generating more decay-resistant fruit.

Season extension for greater fruit availability is important to farmers looking for an edge on local competition and so harvesting from both floricanes and primocanes is increasingly popular. While primocane fruiting varieties tend to have higher yield, our study showed that the primocane crop is harder to manage after harvest in the Mid-Atlantic region. Both bleed and decay susceptibility were found to be more severe during the primocane season.

For both the red-raspberry and yellow-raspberry genotypes, rankings based on floricane fruit were not similar to rankings based on primocane fruit. Since floricane performance was not a good indicator of primocane performance, it is important to screen genotypes in both fruiting seasons when making breeding selection decisions. Eight genotypes in this study could be used to determine whether postharvest decay and bleed using floricane fruit would be similar to that in primocane fruit. Averaged over all genotypes, time to 25% decay was significantly shorter for primocane fruit than for floricane fruit ($p<0.0001$). Floricane fruit took 10.5 days to reach the 25% threshold whereas primocane fruit only took 8.4 days (Fig 2). However, the decay rate for each cultivar during the floricane season was not significantly different from its primocane season, except for 'Kiwigold'. In that cultivar, the decay rate was significantly greater for the primocane fruit, while, the primocane fruit of the red raspberry cultivars 'Caroline' and 'Prelude' appeared to have a slower decay rate than the floricane fruit. However, the difference was not statistically significant.

Similarly, for time to 25% bleed, primocane fruit reached that threshold significantly faster than floricane fruit when averaged across all genotypes. Floricane fruit took an average of 13.2 days whereas primocane fruit took an average of 10.3 days to reach that threshold (Fig 3). Again, the bleed rate for each cultivar during the floricane season was not significantly different from its primocane season, except for 'Heritage,' with primocane fruit bleeding significantly faster than floricane fruit.

When cultivars were ranked from best to worse for decay, the rankings for yellow and red raspberry cultivars were not all similar across seasons (Fig. 2). 'Anne' and 'Kiwigold' switched orders from one season to the next, as did the red cultivars. In the floricane season, 'Mandarin' was the best, and 'Caroline' was the worst, while in the primocane season, their ranks were reversed. For bleed rankings, only the red raspberries were dissimilar for the two fruiting seasons (Fig. 3). Similar to the decay rankings, 'Mandarin' was the best and 'Caroline' the worst during the floricane season, but their ranks reversed in the primocane season. These findings indicate that fruit of primocane-fruiting genotypes should be evaluated from both the floricane- and the primocane-fruiting seasons.

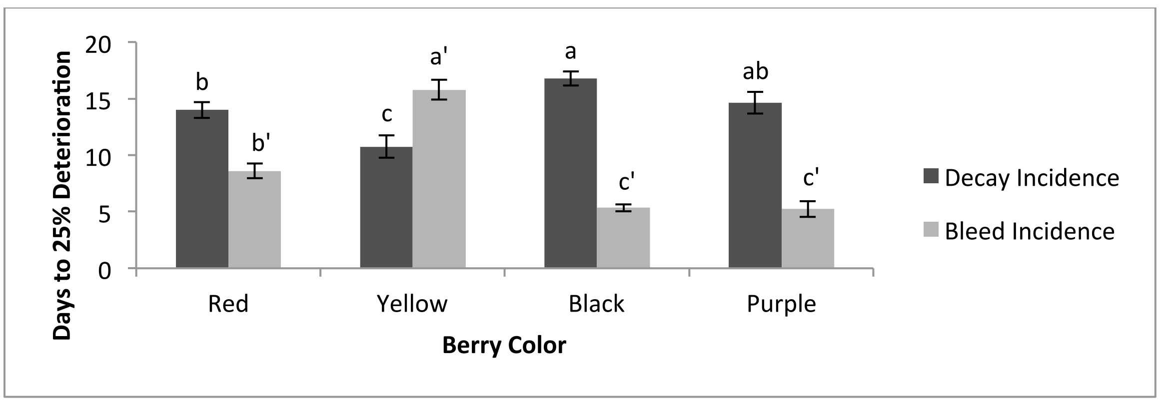


**Figure 1. Mean decay and bleed incidence values for four different colored raspberries stored at 5°C for 2010 and 2011. Means followed by the same letter are not significantly different using the Tukey mean separation method (p=0.05). Note that the shorter bars indicate a shorter shelf life.**

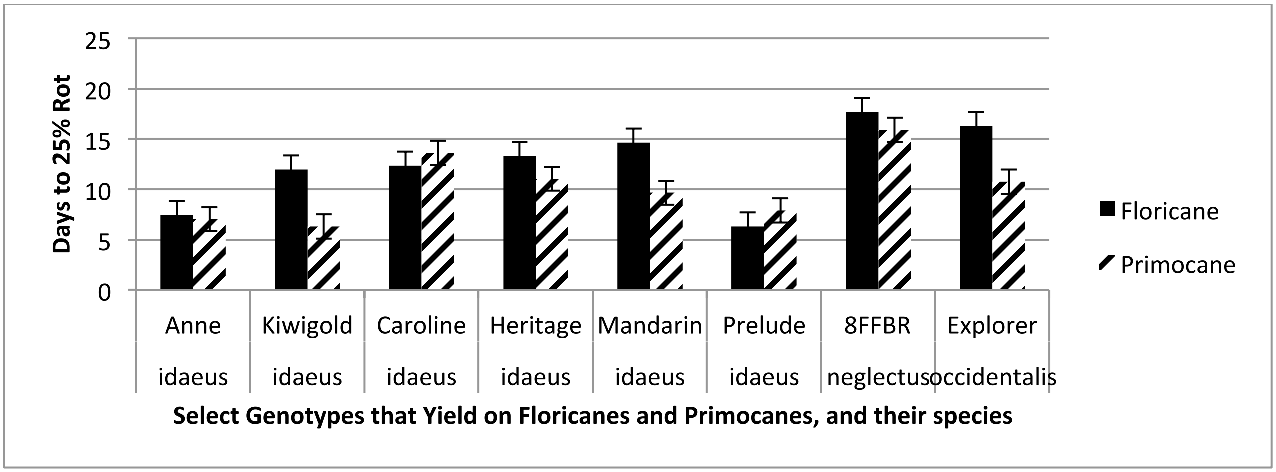


**Figure 2. Mean decay incidence of eight field-grown raspberry genotypes harvested in both the floricane and primocane fruit season and stored at 5°C. Note that shorter bars indicate a shorter shelf life.**

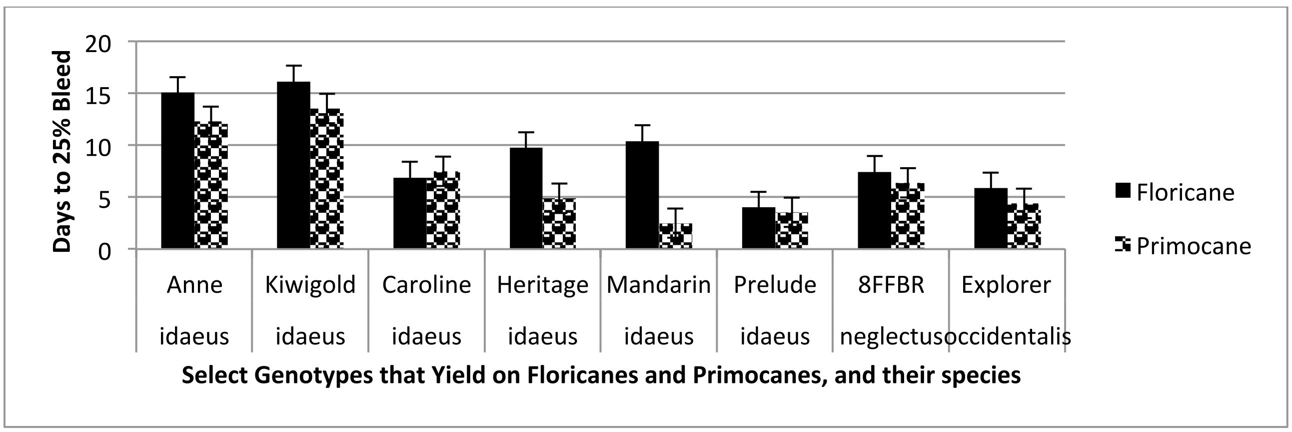


**Figure 3. Mean incidence of bleed for eight field-grown raspberry genotypes harvested in both floricane and primocane fruit season and stored at 5°C. Note that shorter bars indicate a shorter shelf life.**

Several conclusions can be drawn from this study on the four commonly grown colors of floricane- harvested raspberries.

1. The mechanism controlling decay and bleed are distinct and mediated by both biotic and abiotic factors.
2. The colors of fruit that performed well for well in our assessments of storage rot frequently did well in our storage bleed studies.
3. Firmness, while important on its own, had been expected to correlate with bleed and decay resistance. This was not observed in our studies.

**For more information about our recent raspberry research see:**


Harshman, J.M. Lewers, K.S., Jurick II, W. M. and C.S. Walsh, 2013. Resistance to *Botrytis cinerea* and Quality Characteristics during Storage of Raspberry Genotypes. HortScience. (*In press*).

## Nourse Farms Cane Berry Post Harvest Handling 2013

Nate Nourse
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nnourse@noursefarms.com

### Overview

Harvesting Primocane and Floricane Red, Black and Yellow Raspberries, and Blackberries on 14 acres.
Berries are harvested every other day into half pint pulp baskets.
The best berries are transported to the cold storage.
Virtually no customer complaints, 1-2 per season!

### Basic Strategy-Two distinct procedures

Harvest all ripe fruit from plants including some under ripe and packing to ensure few to no bad berries present.
All fruit not sold that day is cooled to 33 degrees. Maintaining cold chain is very important!

### Harvesting

The best berries are delivered to the cooler.
Pickers have standards and procedures. Less than 20 bad berries per 6 half pint bucket.
Packers/Supervisors re-grade and pack berries into half pint pulp baskets.

### Cooler and Cold Chain

Regularly double check cooler temperatures with calibrated thermometers.
Most cooling equipment needs to be set 1 degree cooler to reach desired temperature.
Use temperature recorders to monitor/chart hourly by week.
Additional fans to help facilitate cooling and drying of berries.
We prefer to cap berries after cooling to reduce condensation.

### Critical Issues

Pay close attention to cooling system for ice buildup.
Set defrost clock to function during the night and early morning.
Respiration rates double from 32 to 41 degrees F causing shelf life to be cut in half.

**Key Features for Organic Berry Crop Production**

Marvin Pritts
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Cornell University
Ithaca, NY 14853
mpp3@cornell.edu

Berry production by whatever means is challenging. One has to be good at horticulture, pest management, labor management and marketing to be successful. Producing berries organically is even more challenging. One could debate endlessly the keys to successful organic berry production. In the opinion of this writer, 90% of the groundwork for organic production is laid before and during the planting year – not after the plants are established.

No matter if you are growing conventionally or organically, ensuring that the site you select has good internal drainage is absolutely critical for the planting to sustain any sort of reasonable production over time. This is particularly true for raspberries, but even blueberries will not thrive where the soil is poorly drained. If the soil is poorly drained and you cannot locate elsewhere, then install subsurface drainage or plant on raised beds. There is nothing that can rescue declining plants from wet, saturated soils and the associated pathogens.

Another critical step for successful organic berry production is ensuring relatively weed-free fields at planting. This includes weed seeds and viable root pieces. Once berry plants are established, controlling weeds is difficult. However, if berry plants establish first, then it is more difficult for weeds to compete. It is not unreasonable to cultivate and plant successive cover crops for two or three years prior to planting berries. The investment in weed management prior to planting will pay dividends later on. After planting, the use of mulch can impede weed establishment, and in most cases, benefits berry plant growth as well.

Proper nutrition is also a key to success, especially since many sources of organic fertilizers are slow to release their nutrients. Building nutrient reserves when appropriate (according to soils test recommendations) with amendments and compost before planting can help plant establishment significantly. Also, it is critical that the soil is the proper pH prior to planting. Many growers do not acidify the soil adequately for blueberries, nor do they raise the pH to sufficient levels for raspberries. This compromises the ability of plants to acquire nutrients, and can affect growth and fruit quality.

A fourth step is good selection of cultivars. It is difficult to make recommendations for specific locations about the best cultivars to grow organically. My solution is to ask other local organic growers what varieties they have had success with, and follow their lead.

A fifth step early on is to plant the berries so that they will not be too crowded or difficult to manage when they mature. Also, planting in such a way that ensures good air drainage and minimizes soil run-off will help reduce pest pressure on the planting.

Once the plants are established, the major focus should be on plant management. A sure way to have insects and pathogens infest the planting is to crowd plants together and not trellis or prune them properly. Information is available on the best ways to prune and train brambles and blueberries to ensure high yields while keeping pest pressure low.

The market is full of organic chemical products that supposedly control pests once they have infested a planting. However, these tend to have a broad spectrum of activity and use rates are relatively high. They are also relatively expensive. Growers would be much better off investing time and energy preventing pests from establishing and ensuring adequate pre-plant nutrition than to depend on later interventions to rescue them from pests.

Regardless if one is an organic or more conventional grower, the philosophy regarding crop management is the same: investments up front (before planting) pay the biggest dividends. Conventional growers have more rescue treatments at their disposal, but these have many limitations as well. One should not plan on chemical interventions to provide rescue from poor planting and lack of up-front investment in addressing soil physical, biological and nutritional properties.

## Engineering High Tunnels for Better Performance

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At a cost of $1 to $2 per square foot, a high tunnel can add low-cost growing space for season extension or plant protection. Growers and researchers are finding many innovative ways to utilize these structures.

By definition, the high tunnel is a walk-in, hoop or gothic-shaped, pipe frame structure that is covered with a single layer of film plastic. It generally does not have electricity and the only heat is provided by the sun. Ventilation is by rolling up the sidewalls and opening the doors. Irrigation water is provided by piping from another building or water from a nearby pond or stream. Plant production is usually in the soil or soil beds.

These structures have their roots in Europe where they have been used for growing off-season vegetables. Development work in the U.S. has been done at the University of New Hampshire, Penn State University, Cornell University and several other states.

### Tunnel Construction

Site selection is important. A site that gets at least 6 hours of daily sunlight should be selected. As solar heating and natural ventilation are the means of temperature and humidity control, it is important to locate the tunnel away from buildings and trees. If the crops are to be grown in the soil, organic matter and amendments should be added and the soil should be tested. A swale or rock filled trench should be installed around the tunnel to drain rainwater away and prevent water from getting inside.

Tunnels located in northern states should have a gothic shape to shed snow. Galvanized steel tubing or fence pipe is the standard material used for the hoops and should have the following minimum dimensions:

- 1.90” diameter x 14 gauge for tunnels ≥ 26’ wide
- 1.66” diameter x 14 gauge for tunnels < 26’ wide
- 2.00” square x 16 gauge for all width tunnels
- 1.625” x 2.750” oval for all width tunnels

Bows/hoops should be spaced no greater than 4’ on center. There should be at least 3 purlins on tunnels less than 26’ and 5 on those with greater width. Cross ties/collar ties or trusses are needed on tunnels greater than 26’. The frame should have diagonal bracing on the four corners to keep it from racking in strong winds. In snow country, if the tunnel will remain covered during the winter 2 x 4 wood posts should be placed under the ridge for support about ever third or fourth hoop. Although tunnel length can be any multiple of the 4’ hoop spacing, a 48’ or 96’ length will better utilize the 100’ sheets of plastic that are typically available.

The original use of the high tunnel was for season extension, usually one month in the spring and one month in the fall. The plastic was removed before winter set in. Growers seeing the results that are produced and the increasing demand for the produce grown are now using tunnels for year round production. This presents the problem of keeping the tunnel from collapsing or tipping over from heavy snow and wind conditions.

A 3" wet snow or 12" dry snow adds about 5 pounds/sq ft (psf) to the roof. A 30' x 72' high tunnel would have to withstand a load of 10,800 lbs. Bracing, good connectors, adequate length posts and good plastic attachment are very important. To resist collapsing from heavy snow loads, a few 2 x 4 posts fastened under the ridge have proven to prevent the collapse of many tunnels and greenhouses.

An 80 mph wind creates a force of about 16 psf. The 12' sidewall of the above tunnel would have to be able to take a 13,824 lbs load. The uplifting force on the roof from an 80 mph wind is about 220 lbs/linear foot. To resist this uplifting, the weight of the building and the withdrawal resistance of the posts have to withstand about 300 lbs/post. To anchor the tunnel to the ground, posts are driven into the ground 24" to 30" deep to support the hoops. In windy locations, additional anchors are needed. These can be auger or screw type and placed about 10' apart. An alternative is to install deadmen.

A 2" x 12" baseboard should be attached to the posts with bolts to help make the frame rigid and provide a place to attach the plastic.

The endwalls should have openings at least 6' x 6' for ventilation and access for equipment. The endwall frame and doors can be made of 2" x 4" lumber or steel tubing. Covering for endwalls can be 6 mil ultra -violet resistant polyethylene, double wall polycarbonate or exterior plywood. Solid endwalls are not as desirable as these create a shade that will reduce plant growth.

**Plastic**

Most greenhouse grade polyethylene film is manufactured as a coextrusion of three layers with different polymers and additives. Each of them contributes to the quality of the film and enhances its performance. If the plastic will be removed before winter a 4 mil greenhouse grade should be adequate in most locations. If it will be left on all winter then it is best to utilize the stronger 6-mil greenhouse grade. In windy locations, a woven polyethylene has given better service. For heated tunnels, a double layer with air inflation will reduce heating costs by about 35% and allow snow to slide off easier.

Plastic with an infrared (IR) inhibitor traps the inside radiant heat from escaping. In heated greenhouses, the savings have been measured to total from 10 – 20% depending on whether the sky is cloudy or clear. Research at several universities has been inconclusive as to whether the IR additive slows warming of the tunnel in the morning. In research at Penn State University during October, the tunnels warmed up significantly faster in the morning than outdoor ambient but there was no difference between standard poly and IR poly. During the day, the IR film did not increase the overheating problem as compared to standard clear poly. At night, the tunnels with the IR film retained heat better than the standard poly by 2 - 3ºF but with both types the tunnel was cooler than outdoor ambient.   In heated tunnel, double layer poly installations, the IR film is always placed as the inner layer to retain nighttime heat.  IR film costs about 1 - 2¢/ sf more than regular poly.

Early failure of poly can be attributed to stress on attachment points, abrasion on rough surfaces and sharp edges or heat build-up in that area of rafters, purlins and extrusions.  Contact with chemicals from pesticides or pressure treated lumber can also affect the life of the plastic. Poly that is left on the tunnel during the winter is subject to cuts from blowing ice especially if there are multiple tunnels adjacent to each other. A scrim reinforce poly may be desirable in this situation.

A hip board, attached to the frames, 3’ to 4’ above the baseboard will hold the plastic when the roll-up sides are installed.  The plastic is attached to the baseboard and hip board with aluminum extrusions or a double furring strip for a tight seal and easy replacement.  Guy ropes from the hip board to the baseboard keep the plastic from billowing out in the wind.

**Movable tunnels**

If the crops will be grown in the soil, the structure could be installed so that it can be easily moved from one plot to another.  This allows a cool season crop to be started early in the spring and then when the temperature warms up the tunnel is moved to another plot for the production of tomatoes, cucumbers or peppers.  One method is to weld the hoops to a 3” x 3” x ¼” thick steel angle.  The ends of the angle are bent up to form a skid.  The tunnel can be pulled by a couple of tractors or by two winches.  Another method is to attach “V-groove wheels to the bottom of the hoops and have them ride on an inverted angle iron.  There are several manufacturers that sell movable tunnels.

## Heating and Cooling Alternatives for High Tunnel Tomato Production

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### Cooling

Summer cooling is usually done through roll-up or drop-down sides and endwall doors. Cost is about $10/linear foot. Roof vents have been installed in some tunnels but are expensive at about $40/linear foot. Ken-Bar, Inc., Reading MA makes small manual and automatic vents that can be inserted into the roof to reduce the temperature about 5ºF if installed on a 20' spacing. If crops are to be grown during the summer, shade cloth could be placed over the tunnel to reduce the inside air temperature. It is available from 5 to 95% shade. Cost is about $0.20 to $0.40/sq ft. A summer crop of tomatoes usually requires about 50% shade. Fan ventilation could be installed at about ½ volume air change/minute for early spring operation. When it warms up then roll-up sides are opened. Motorized equipment requires an electric service.

### Heating

For early season crops such as tomatoes, cucumbers and peppers, a root-zone heating system should be installed. This system utilizes a propane gas hot water heater, circulating pump, 1/2" or ¾" diameter tubing or pipe and a remote bulb thermostat to maintain a 70 to 75ºF soil temperature in the root zone. Electricity will be needed to operate the pump and controls.

The least expensive pipe is polyethylene, which is available in 100' and 400' rolls. Select a pipe made of virgin plastic rather than one having reconstituted resins. It should have a pressure rating of at least 100 psi.

Commercially available systems are available that use EPDM rubber tubing either as single tubes or as two or four tubes attached to a web. Diameters of 3/8" or ½" a have greater heat transfer and eliminate some problems from chemical coating and sedimentation blocking. Cross-linked polyethylene (PEX) tubing in 5/8" or ¾" diameter can also be used.

The size of the water heater or boiler depends on the amount of area to be heated and the cropping system used. For tomatoes grown in rows in the soil or in bags with a single line of pipe under each row, you can estimate that it takes 10 Btu/linear foot of row length. Add about 10% to this total for heat loss from the supply pipes. The soil around the pipes needs to be kept moist to get good heat transfer.

A tank-type, domestic hot water heater (30,000 to 40,000 Btu/hr) fired by natural gas or propane will provide the root zone heat for a tomato growing area up to 6,000 sq ft. Multiple water heaters can be connected together with a manifold to get higher outputs.

In the simplest system using a water heater, the thermostat on the tank is set at the desired root zone water temperature (usually 100 deg F). Return water from the loops goes back to the tank to be reheated. Activation of the circulating pump is done with a remote bulb thermostat inserted in the soil or growing bag. An electronic thermostat is a good choice as the differential between on and off is only a degree or two. Mechanical thermostats have a greater differential.

Air heat may be needed on cold nights. A non-vented heater may be ok for a night or two but tomatoes are very sensitive to sulfur dioxide and ethylene gas from combustion of fossil fuels. This will show up as white spots on the leaves or misshapen leaves. A better choice for heat is a vented heater, either a unit heater or a furnace.

**Irrigation**
Irrigation water is needed for the plants. If zoned properly, several high tunnels may be supplied by a 1" or 1-1/4" poly pipeline. Where the tunnels are located a distance from water, a trailer mounted tank could be used for the water supply. For crops grown in rows or containers, a drip system will reduce the amount of water needed.

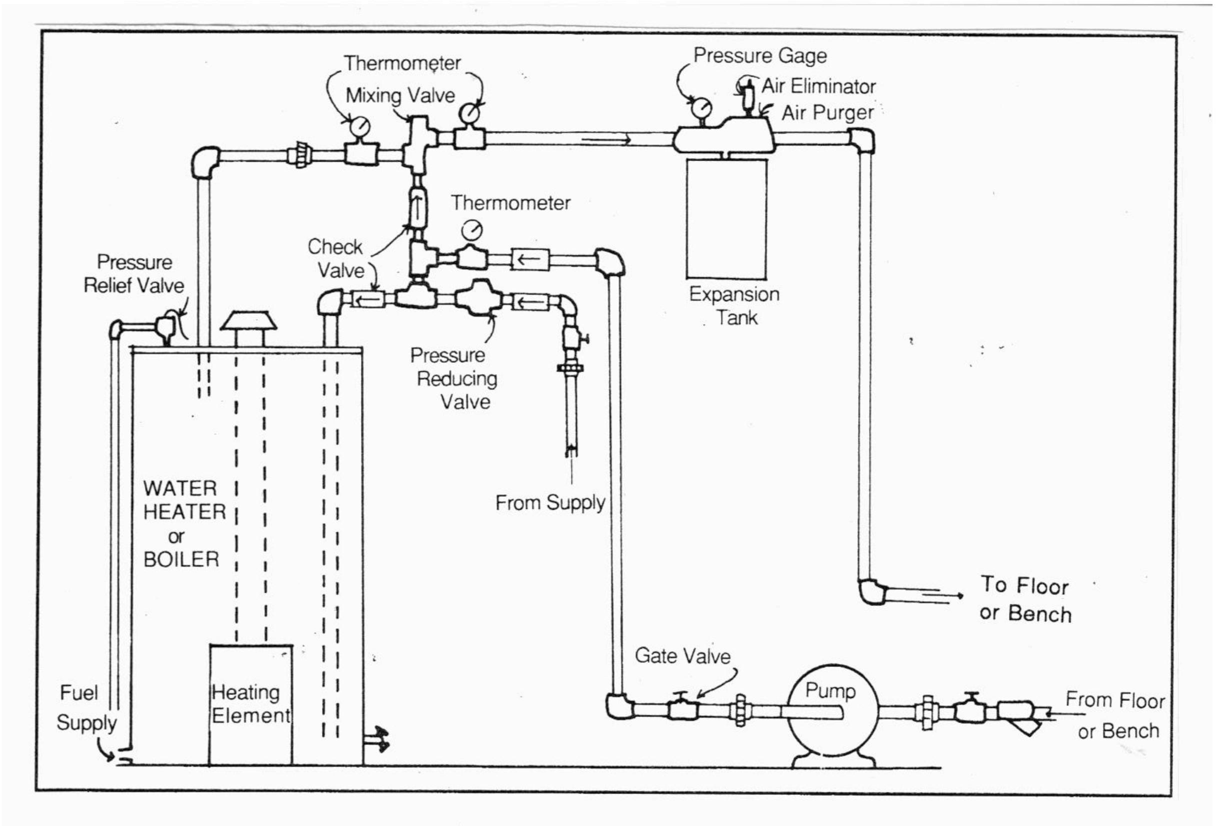
Although high tunnels can't provide the same environment as a greenhouse, they can offer a grower the opportunity to have additional growing space during the spring and fall for crops that are not highly temperature sensitive. They do require more attention and maintenance.

**References:**
**Production of Vegetables, Strawberries and Cut Flowers Using Plasticulture** – NRAES-133 – 146 pgs. Available from www.palspublishing.cals.cornell.edu.

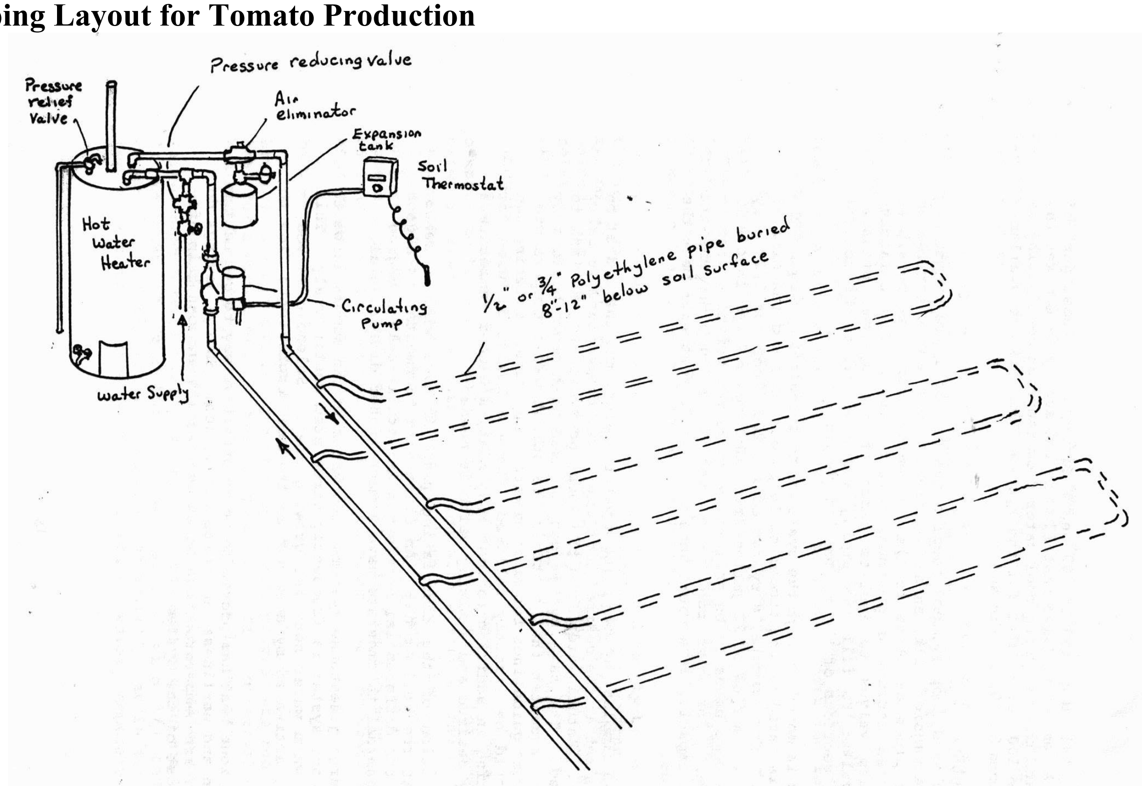
**Greenhouse Engineering** – NRAES-33 – 212 pgs. Available from www.palspublishing.cals.cornell.edu.

The following information sheets are available from the author at jbartok@rcn.com
Plastics on Tunnels for Different Seasons
Bottom Heat for Tomatoes
Design and Layout of a Small Commercial Greenhouse Operation
A Few Pointers for Better Irrigation

## Schematic of Typical Root Zone Heating System




## Piping Layout for Tomato Production



**Timing Cultivations for Maximum Weed Control**

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Effective cultivation is essential for weed management in organic and many diversified vegetable cropping systems. There is a great diversity of cultivation tools in the market place, with some particularly innovative intra-row weeding implements being produced in Europe. Evaluating cultivation practices generally includes measurements of efficacy, i.e., the proportion of weeds killed by the cultivation event; and efficiency or working rate, i.e., acres, beds, or row-feet per hour or minute.

Detailed experiments characterizing cultivator efficacy involve pre- and post-cultivation censuses of weeds at particular locations, generally by species and growth stage. Efficacy may be affected by many, sometimes interacting factors: equipment design and adjustment; speed; soil conditions, especially moisture; and weed factors, including species and growth stage.

We recently conducted a series of experiments measuring cultivation efficacy at a field scale. In each of three years, cultivation efficacy and soil conditions were measured at 70 locations, randomly selected along five corn row transects in 2-4 acre sized fields of silage corn. The cultivator was a common, older model, 3-point-hitch-mounted, 4-row Case International Model 183 with Danish s-tines and 10 cm sweeps and gage wheels. Condiment mustard, 'Idagold,' (Sinapis alba) was used as a surrogate weed. Soil surface roughness, soil bulk density and texture were measured, as was soil moisture. Efficacy was even more variable than expected, ranging from 6.7 to 100%, with mean and median values of 67 and 68%, respectively. In one year, soil moisture explained nearly 10% of the variation in efficacy, but in other years, contrary to expectations, soil conditions failed to explain any portion of the considerable variation in efficacy. An important research objective related to improving cultivation is to better characterize and understand the sources of this variability. Moreover, it would be very useful to know if improved designs of conventional sweeps could reduce some of this variability.

Despite knowledge gaps related to variability in cultivation efficacy, research and farmer experience offer several important principles regarding timing of cultivation:

1) Efficacy is inversely related to weed size (smaller weeds are easier to kill). In one of our recent experiments, average control of mustard was reduced by 10% with each added leaf. It is also notable that variability in efficacy increases with increasing weed size.
2) Targeting very small weeds is more important for "blind" cultivators, i.e., rotary hoes and spring-tine harrows, and for intra-row weeders, i.e., finger and torsion weeders, than for

inter-row weeding tools, typically sweeps, which can provide good control of even relatively large weeds.

3) Efficacy is generally better during hot, dry weather and dry soil surface conditions as uprooted weeds more rapidly desiccate.
4) Crops with a size advantage can be more aggressively cultivated; establishing and maintaining an initial size advantage is essential. Stale seedbeds, pre-emergence harrowing, or use of transplants are effective ways to establish an initial size advantage to the crop.

Cultivation references:

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**Greenhouse-grown Figs**

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I have been attempting to grow figs commercially ever since an old farmer took me to the south side of his storage barn and pulled a fully ripe Brown Turkish Fig off his large bush and proudly said, "eat this and you'll be half way to becoming real Italian gourmet". I had never eaten a fig before and, with the first bite, I was hooked! His technique was to get a hardy Brown Turkish Fig variety and plant them on the south side of his barn, which had a deep cement foundation. During the fig trees' first five growing seasons, he would cut the right hand side roots back to the root ball. This would allow him to train the tree to easily hinge on its left hand roots and lean over each winter to go dormant lying on its side covered in leaves and a large heavy canvas tarp. He also put a ton of "D~Con" amongst the leaves to keep the vole/mouse population down. Each spring he would right the tree, give it some well-rotted cow manure and a sprinkle of potassium and walk away till September. At which time he would convert everyone he knew to Italian gastronomical theology.

Our attempt at replicating this concept was to grow Brown Turkish Figs in large 10-gallon containers in our greenhouses. This worked O.K. until I had collected 30 of them and my wife said, after ten years of dragging them in and out, it was me or the figs to the compost pile. Undaunted, I found a well-drained area in our fields and tried planting them in the ground. They did great during the summer, but in the fall I had to figure out what to do with the overwintering challenge. I knew I did not want to start cutting roots and leaning them over, because I was missing one of my mentor's key ingredients, his cement foundation that absorbed heat from the sun everyday and translated it down the wall to the roots. For two years we tried Johnny's tall electrical conduit hoops and double and even triple covering them with multiple layers of remay and plastic. But each year the plants would have all their above ground branches buried back and they would have to start from ground up making a new scaffolding of branches; and of course, gave us no figs! Fast forward: Two years ago we had an old 14' wide by 150' mini greenhouse we no longer needed. We took it apart to cover our fledging fig field operation. We replaced the old ground pipes with much taller ones and, in doing so, jacked the greenhouse up so the new peak was 14' tall and not 8'. (By the way this isn't tall enough. I should have gone taller to 16'.) I have repeatedly been warned by Ed Pearson of Ledgewood Greenhouses to never jack up his houses beyond their design, but I have found the 14' houses shed snow so well that I thought it would work. The problem will be getting the snow away from the sidewalls, if there is a substantial snow.

We fitted the sides with high rollup sides to keep it cool during the summers. One of the most important custom additions was adding a 16" by 4' wide hinge~able window above each 4' door at both ends of the greenhouse. One of the challenges of growing figs trees is keeping them dormant during the depth of winter. If it is a sunny day we need to keep the greenhouse from heating up too much (or waking up the trees). So we have these little windows to allow the heat to escape. Only on the coldest nights do we close the windows. Our first year with the 14’ foot greenhouse gave us tremendous growth and wonderful figs. But preparing our figs for winter, we knew we had to cut them back and wrap them some how. We hacked them back 80%, wrapped them with shredded (on the way to the dump) old remay and took old one-ton fertilizer bags and covered each tree. This worked great but for the fact it gave every mouse and vole in town a place to over winter and chew on all our branches!

The next year we strung a 3/16th wire cable from the top of the door at each end and pulled a piece of heavy remay over the entire run of trees. We still were worried so we found a heavy perennial ground cloth from Griffins Greenhouse supply that seems more like a dense shammy cloth. It is only 15’ wide but it worked perfectly to fit over the line of pruned trees like a pup tent. The operative detail is to create an area that is insulted and that allows the ambient ground heat to radiate upwards from the bare ground to the branches to keep them above a deep freeze. We had a thermometer two feet off the ground last year and it never got below 28 degrees even when it was 16 degrees outside.

In spring, we dust the ground with compost and some Krehers’ 4,3,3 composted chicken fertilizer. Next year we will put down some straw. Weeds have been a problem. Caution! If you do spring or summer pruning be careful not to let the milky juice from your cuts get on your skin, eyes, etc....it is quite caustic!

We had no visible bug problems until this fall when we suddenly had fruit rotting just as it was time to pick! About the same time we saw tiny white milky juice coming out all over the ripening figs. It was SWD! How stupid did we feel! Next year we will be more vigilant about monitoring their arrival and making sure any bad fruit is removed.

Our plants are centered in the 14’ house and the distance, “in row”, between the plants is 8’6”. In year three of getting them to over winter, we are thinking 10’ “in row” might be a little better. Also, this next season we will be removing the greenhouse cover early July to let the trees have better light and less heat build up during the dog days of summer. Watering is huge during the summer and to keep them happy we put four drip lines over the 14’ width. I suspect we have two spotted spider mite problems, so I may be spraying a type of dormant oil on the trees at some early juncture next season. Another source of income is taking cuttings of the fall-pruned branches! Farmers market patrons all love a story about how to grow figs in their back yard. The one-gallon cuttings bring a easy $10 a plant!

This season we were averaging about 4.5 lbs. per plant and getting $13.00 a pound. We think with some early summer pruning we could get up to 7 lbs. a plant. Frankly, we are too busy with everything else to fine-tune it too much.... Like raising ginger, you do it for the visibility and presence at your markets more than for the dollars they represent. But at this point, I have eaten so many I can almost understand the Sicilian dialect and now know how to cook Cardoon!

## Pawpaw, a hardy fruit with tropical aspirations

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Pawpaw (*Asimina triloba*) is a native fruit whose uniqueness and flavor accord it good commercial potential. The plant and fruit seemingly have tropical aspirations: Pawpaw is the northernmost member of the mostly tropical custard apple family and the tree looks tropical with large, lush leaves. But mostly, the tropical-ness is with the fruits, which hang in clusters, as do bananas, and appear reminiscent of mango. Inside is a creamy, white, custardy flesh tasting much like that of bananas, with additional hints of vanilla custard, pineapple, and mango. Tropical "roots" notwithstanding, pawpaw tolerates winter temperatures at least to minus 25 degrees Fahrenheit.

Being easy to grow is another plus for pawpaw as a commercial fruit. The tree requires little pruning and is relatively free from insect and disease problems. As such, pawpaw is well suited to "organic" or "sustainable" production and marketing.

Even the rose has its thorns, and pawpaw does have its quirks that need attention. A taproot makes transplanting require at bit more care than involved in transplanting. Getting plants from a specialty nursery improves results. Also, the peduncle is for a cluster of fruits, with the abscission layer where the peduncle meets the stem; a wound, therefore, is left on each fruit where it detaches from the cluster. Flowers open over a long period of time so fruits on a given tree likewise ripen over a period of time, spreading out harvest date, which can be an advantage or disadvantage. Perhaps the greatest challenge is in handling and storing the fruit, which is soft and easily bruised, and probably not suited to long-term storage.

The above challenges are less of an issue for small farms and local sales. At this scale, customers can taste the fruits, the flavor of which usually sells them right there. The long harvest period means a long period of sales. The long bloom period makes the trees less susceptible to late frost damage than most other tree fruits. In my testing, fruit can be made available though harvest and storage from about the middle of September until about the middle of November. The pulp can be extracted and frozen for long-term storage.

Okay, let's plant pawpaws. Site requirements are similar to that of other fruits: sun and well-drained, moderately fertile soil. The fruits do need sufficient summer heat to ripen – about 160 days or 2600 growing degree-days. Although most seedling trees have at least reasonably good flavor, planting a named variety (i.e. a grafted tree) – two different ones, for cross-pollination – gives better assurances of quality as well as larger fruit and earlier production. Recommended spacing is 10 to 20 feet within the row. Trees naturally develop good form so little training is needed beyond removing crowding branches. As tree ages, periodic heading cuts stimulate growth of new wood on which fruits are borne. Pruning also thins out potential fruits, which may increase size of those that remain as well as avoid limb breakage.

Virtually no care is needed during the growing season. Trees do sucker; I go through the planting two or three times during the growing season to cut them off.

In USDA hardiness zone 5, ripening begins around the middle of September. Ripening is signaled by softening of fruits and skin color becoming speckled brown (similar to banana!).

Ripe fruits also drop. I harvest fruits from the ground. Harvesting from the ground dictates another wrinkle in pruning: Fruits that drop from too great a height get damaged upon landing, so I head trees to no higher than about 10 feet. I also mulch the ground beneath the trees with hay to soften the impact upon landing.

Harvested daily and whisked into the cooler at 39 degrees Fahrenheit, sound, dropped fruit keep well for at least two to three weeks. Dropped fruits are not all at the same stage of ripeness. Firm fruits soften and improve in flavor over time. In fact, flavor can change dramatically during softening and ripening, with people differing with their preferred stages of ripeness.

Pawpaw fruits have been very well received in test marketing via direct sales (with tasting) and restaurant sales. Depending on markets, returns have ranged from $6 to $12 per pound, making pawpaw a fruit with good market potential.

For more details on the history, cultivation, and varieties of pawpaw (as well other interesting and commercially viable, “uncommon,” fruits), see my book *Uncommon Fruits for Every Garden*, Timber Press, 2004.

**BOGS Online Grower System, a Record Keeping and Pest Management Decision Tool**

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The BOGS Online Grower System is an Internet-based application tool developed for Massachusetts cranberry growers. It is primarily a pesticide and nutrient management application but also is able to record other horticultural/cultural practices, as well as an insect pest identification and decision making control guide. Although designed for Massachusetts cranberry producers, it has received interest from New Jersey cranberry growers and recently, other commodities.

The purpose of this presentation is to give attendees a better understanding of what the program does, how it works and an opportunity to better understand if it, or something similar, may prove useful for other crops. The presentation will feature an overview of how the system was created, how it works and how growers are using it as part of their on-farm management. The presentation will also have a real-time walkthrough of inputting data and generating reports. As time permits, current enhancements in progress and future plans can also be discussed.

BOGS has all of the labeled pesticides for use on Massachusetts cranberry bogs, with the accompanying active ingredient, EPA registration number, PHI, REI, etc. Through a series of easy to use menus and free-text entries, growers are able to input their pesticide applications, with warnings on maximum/minimum label rates, total applications allowed per season, groundwater restricted use chemicals and more. Reports are available for summarizing treatments by bog or contract, along with the required handler and state pesticide use reports.

Fertilizer applications can be similarly input. There is a calculation area to assist in identifying how much fertilizer is required based on input criteria. In addition, users can record their IPM insect scout data, tissue and soil test results, water use and sanding applications (sanding is a common cranberry cultural practice where every few years, a layer of sand is added to the surface of the cranberry bog).

Besides inputting data, BOGS can be used to identify insect pests. There are many insects pests on cranberry bogs and many of them are similar or otherwise difficult to identify. Through a series of "If/Then" questions, growers can identify or narrow down what pest they may have encountered. After identification is complete, answering an additional series of questions delivers control options to consider. Further questions are asked, including environmental factors and efficacy, to help the grower understand what control options make the most sense for their operation.

One of the powerful features of BOGS is that it records data in real-time, from potentially anywhere. As long as there is an Internet-connection, BOGS can be accessed. Since it's an Internet-based tool, there is nothing to download or install. Many growers utilize their Smartphones or tablets to record data while still in the field. All of the historical data is available at any time, with no fear of losing records or hard drive crashes. The BOGS Online Grower System is helping to increase on-farm efficiencies, improve decision making, enhance required regulatory compliance, while simultaneously helping to develop and sustain market opportunities.

**Hardy kiwifruit, better than the fuzzies**

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Hardy kiwifruit (*Actinidia arguta*) is cousin to the fuzzy, market kiwifruit (*A. deliciosa*), with some similarities and some differences. A big difference is the "hardy" part. Fuzzy kiwi plants are hardy only to Zone 7 and need at least 200 days to ripen their fruits. Hardy kiwifruits are hardy to Zone 4 and ripen their fruits in 150 days. (Actually, there are two species of so-called "hardy kiwifruits;" the other, *A. kolomikta* is hardy to Zone 3 and ripens its fruits in 130 days but has commercial limitations that keep it from consideration here.)

Hardy kiwifruits are small, grape-sized, but with smooth, edible skins so can be popped into your mouth like grapes. Inside, the fruits look the same as the insides of fuzzy kiwifruits. The flavor of the two is very similar, except that hardy kiwifruits taste better, with more sweetness and aroma.

Every plant has some limitations, so, before going further, let's get hardy kiwis' out of the way. The plants are rampant vines, so need trellising for good management. Most common, and the way I grow them, is on a 5 wire, T-trellis with 5 to 6 foot wide cross arms. Annual pruning is needed, during the dormant season and then, ideally, a few times during the growing season. Hardy kiwifruit plants are dioecious, so (nonfruiting) males are needed to pollinate females, which do fruit. One male can sire up to about eight females. Although the plants are quite winter cold-hardy, growth begins early in the spring and that early growth is susceptible to late frost injury. Flowering can still occur following some injury, depending on the growth stage and the degree of injury. In my experience, plants seem more frost tolerant as they age.

The above limitations aside, hardy kiwifruit are relatively easy to grow. A number of varieties are available. Anna (Ananasnaya) is a common commercial variety; Dumbarton, Geneva, and MSU are others, ripening earlier, an important consideration the further north plants are grown.

Pests or diseases generally do not pose any problems with hardy kiwifruit. As such, they are well-adapted for sustainable or "organic" production and marketing.

The goals in training and pruning are to make a potentially tangled mass of rampant shoots manageable and easy to harvest, and to keep a vine fruitful by allowing adequate light to fall within the plant canopy. Pruning also stimulates an annual flush of new wood, important because flowers and, hence, fruits, are borne only toward the bases of shoots of the current season that grow from the previous year's canes. An established actinidia vine consists of a trunk, 2 permanent cordons running in opposite directions along the middle wire of the trellis, and fruiting arms (or canes). Fruiting arms grow perpendicular to the wires and cordon, and are tied down to drape over the outside wires.

Annual pruning consists, first, in shortening the ends of the cordons each winter to prevent further elongation, and then in maintaining a supply of fruiting arms. The fruiting arms give rise to laterals that bear fruit at their bases; during each dormant season, these laterals are shortened to a few buds beyond the point at which they fruited---eighteen inches long is about right for each lateral. When a fruiting arm with its lateral, sublateral, and subsublateral shoots is two or three years old, they are all cut it away to make room for a new fruiting arm originating directly from the cordon.

Summer pruning is aimed at keeping vines in bounds, maintaining order, and letting the shoots bask in light. Repeated summer pruning, as needed, is required through the growing season, paying special attention to the vine during the critical, early part of the growing season. When a vine is getting enough sun, the ground beneath should be in dappled shade.

A mature hardy kiwifruit vine can produce one hundred pounds of fruit. Harvested fruit will ripen off the vine, but only after achieving a certain level of maturity. Sweetness and firmness are two indicators of when a fruit is ripe for picking. A refractometer reading of eight to ten percent soluble solids is one indicator; another benchmark of when to harvest is when the first fruits on a vine start to soften.

Mature, unripe fruit will be hard, but will soften and sweeten in a week at room temperature. If the fruit is refrigerated to near freezing, and humidity maintained at ninety-five percent, the fruits will keep for many months! Let firm-ripe fruit soften before eating.

A marketing plus for hardy kiwifruits is that they can ride on the coat tails of fuzzy kiwifruits, with which consumers are familiar. The best selling point for hardy kiwifruit is their delectable flavor.

For more details on the history, cultivation, and varieties of hardy kiwifruits (as well other interesting and commercially viable, “uncommon,” fruits), see my book *Uncommon Fruits for Every Garden*, Timber Press, 2004.

**Effect of Increasing Population on Ear Size of SE Synergistic Sweet Corn, var. 'Montauk'**

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**Introduction**

The sweet corn variety 'Montauk' is a popular variety among fresh market producers. It is consistently a customer favorite for its excellent flavor and large size. But for wholesale growers it can be a challenge. Variety evaluations at Purdue University in 2010 showed Montauk to be among of the largest in size and the heaviest ear of 11 SE varieties tested. Wholesale growers in Connecticut have complained that Montauk is too large an ear to fit sixty ears in a standard 5-dozen bag.

Several growers have reported increasing sweet corn populations of certain Synergistic SE varieties such as Montauk to as high as 40K plants per acre without a decrease in quality. Typically the effects of increasing population would be a decrease in individual plant size due to limited resources such as fertilizer, water and space. With Montauk, a reduced ear size with no drop in quality would be a good thing. So a field experiment was conducted to determine if increasing population size will decrease ear size, making it easier to pack, while remaining marketable.

**Experimental Design 1:** This experiment was conducted at the Griswold Research Center in Griswold, CT on a very well drained Windsor loamy sand in 2011 and 2012. The experiment design was a randomized complete block design with four replications. There were five treatment populations (25K, 30K, 35K, 40K and 45K plants per acre) in 2011 and 4 populations in 2012 (Table 1). Treatments were planted in blocks 10 feet by 40 feet. Row spacing was 2.5 feet or four rows per plot. Treatments direct seeded by hand at in-row spacing indicated in Table 1.

Table 1. Treatment in-row spacing.

| | **2011** | **2011** | **2012** | **2012** |
|---|---|---|---|---|
| Treatment | Population (plants/Acre) | In-row Spacing (inches) | Population (plants/Acre) | In-row Spacing (inches) |
| 1 | 25,000 | 8.5 | 26136 | 8 |
| 2 | 30,000 | 7 | 29870 | 7 |
| 3 | 35,000 | 6 | 34848 | 6 |
| 4 | 40,000 | 5.25 | 41818 | 5 |
| 5 | 45,000 | 4.75 | | |

All treatments received 60 lb. N – 120 lb. P – 120 lb. K broadcasted and incorporated before planting and were sidedressed with N in the form of ammonium sulfate as determined by PSNT. Weeds were controlled with Lumax herbicide at 2.5 qt per acre. Insects were monitored but no sprays for insects were applied in either year.

**Experimental Design 2:** This experiment was conducted at the University of Connecticut Plant Science Research Farm in Storrs, CT on a Paxton and Montauk fine sandy loam in 2011 and 2012. The experiment used a split-plot design with the main factors being conventional tillage and deep zone tillage (DZT). The sub factors were the population treatments with in-row spacing of 8, 6 and 4 inches and between row spacing of 30 inches. Population treatment plots were randomized within each tillage treatment strip and replicated four times. The field was planted with a Matermacc vacuum planter. Weeds were controlled with a single post-emergence application of Impact (topramezone, 0.75 oz./A), 1% methelated seed oil, and 10 lbs./A ammonium sulfate. All treatments received 120 lb. N – 60 lb. P – 90 lb. K broadcast, either incorporated (conventional-till) or unincorporated (DZT), before planting and were banded with 48 - 24 - 36 at planting. An additional 100 lb./A of urea (45 lb. actual N) were sidedressed in 2011 due to excessive rainfall, but not in 2012.

**Data collection:** Sixty ears were harvested, weighed and packed to evaluate the effect of population on ear size and ease of packing in a five-dozen bag. Ears were harvested from the center two rows of each plot, starting in the center of each plot and leaving at least five feet on each end. From these sixty ears, a random subsample of ten ears was husked and measured in length and width to further evaluate the effect of population on ear size. Tip fill of these ten ears was then evaluated using the following rating scale: 5: kernels filled to tip of cob, 4: < 0.5 inch unfilled, 3: 0.5-1 inch unfilled, 2: > 1 inch unfilled, 1: > 2 inches unfilled. Data was analyzed using linear regression. Tip fill was rated in Griswold and Storrs only in 2011.

**Results:**
**Griswold Yield Data**: The data collected in both years and at both sites showed a trend of decreasing weight and size of ears as population increased. The statistical analysis for this study was linear regression. For our study regression analysis tells us how well you can predict the change in the weight and size of the ear as the population increased. If our data followed a linear regression the ear would get smaller at a steady, predictable rate as the population increased. The yield data are shown in the following tables:

Table 1. 2011 Griswold yield averages

| Population | Weight (lbs.) | Length (inches) | Width (cm) | Tip-fill rating |
|---|---|---|---|---|
| 25,000 | 53.5 | 8.1 | 4.9 | 4.3 |
| 30,000 | 48.6 | 8.3 | 4.8 | 4.0 |
| 35,000 | 53.0 | 8.2 | 5.0 | 3.8 |
| 40,000 | 49.1 | 8.0 | 4.9 | 3.4 |
| 45,000 | 43.4 | 7.6 | 4.5 | 2.6 |
| *Significance F<0.05* | *NS* | *NS* | *NS* | ** |

In Griswold in both years, weight and size of ears were reduced by increasing population. In 2011 the data did not however follow a linear pattern of decrease. Differences are small until you get to the highest population when it drops off sharply. The tip-fill rating showed a strong fit in the linear regression model indicating that the quality of the ear was dropping as population increased. So, from a marketability standpoint, though the size is still sellable (7.5 inches long and 2 inches wide), 1 inch of no tip-fill might not be acceptable.

The 2012 yield data (table 2) followed the linear regression model much more closely. Population increases caused decreases in weight for every treatment. One possible explanation for this is the weather. We had a dry first half of the summer in 2012 which could have amplified the effect of competition even with small increases in population.

Table 2. 2012 Griswold yield averages

| Population | Weight (lbs.) | Length (inches) | Width (cm) | % Skipped |
|---|---|---|---|---|
| 26136 | 54.3 | 8.3 | 5.1 | 7.3 (64.75) |
| 29870 | 51.0 | 8.3 | 4.9 | 12.7 (69) |
| 34848 | 50.1 | 8.1 | 4.9 | 15.9 (71.5) |
| 41818 | 45.3 | 8.0 | 4.8 | 19.2 (74.75) |
| *Significance F<0.05* | * | *NS* | * | * |

While harvesting in 2011, both researchers observed a trend that as population increased there seemed to be more plants that were either too small to harvest or still had yellow silk, indicating a delay in maturity. So, in 2012 these skips were counted as part of the data collection. The number of plants that had to be past by in each plot because of immaturity increased steadily as population increased. The numbers in parentheses in table 2 are the average number of plants it took to get 60 ears.

**Storrs Yield Data:** The weight and ear size decreased as population increased in both years in Storrs for both conventional-till and DZT plots. Tables 3 and 4 show the treatment averages for 2011 and 2012. As was the case in Griswold, the weight of ears stayed relatively equal until the highest population treatment in 2011 which caused a decrease in weight of 14%. In both years, the size of the ear remained similar: length and width measurements varied by 5% or less. All harvested ears had full tip fill in all treatments in 2011 and therefore was not measured in 2012.

Table 3. 2011 Storrs yield averages

| | | Conv | | | DZT | |
|---|---|---|---|---|---|---|
| Population | Weight (lb.) | Length (in.) | Width (cm) | Weight (lb.) | Length (in.) | Width (cm) |
| 26134 | 42.6 | 7.8 | 1.6 | 45.9 | 7.9 | 1.7 |
| 34846 | 42.4 | 7.8 | 1.6 | 46.2 | 8.0 | 1.7 |
| 52269 | 36.6 | 7.6 | 1.5 | 41.4 | 7.7 | 1.7 |
| *F<0.05* | *NS* | *NS* | *NS* | *NS* | *NS* | *NS* |

As part of the experiment design in Storrs, a test was done to compare the main plot treatments of conventional tillage and DZT. A t-test was performed to compare the means of all the measurements in one tillage type versus the means of the other tillage type. In 2011 DZT had significantly higher weight than conventional tillage and visually the kernels and ears appeared more mature. The higher ear weight may reflect improved drainage in the DZT plots in 2011 when over 63 inches of precipitation were recorded in Storrs. There was no statistical difference between the tillage methods for weight in 2012, although weights were slightly higher in conventionally tilled plots. The length was not statistically different in 2011, but it was in 2012, with ears in the conventionally tilled plots being slightly longer than in DZT plots. There were no differences in width between tillage methods in either year.

Table 4. 2012 Storrs yield averages

| | | Conv | | | DZT | |
|---|---|---|---|---|---|---|
| Population | Weight (lb.) | Length (in.) | Width (cm) | Weight (lb.) | Length (in.) | Width (cm) |
| 26134 | 52.5 | 8.0 | 2.0 | 50.8 | 7.8 | 1.9 |
| 34846 | 48.1 | 7.8 | 1.8 | 45.8 | 7.6 | 1.8 |
| 52269 | 43.3 | 7.8 | 1.8 | 41.8 | 7.6 | 1.8 |
| *F<0.05* | *NS* | *NS* | *NS* | *NS* | *NS* | *NS* |

Table 5. Storrs tillage comparison

| t-test | | 2011 | | | 2012 | |
|---|---|---|---|---|---|---|
| | Weight | Length | Width | Weight | Length | Width |
| Conv | 40.53 | 7.736 | 1.585 | 47.96 | 7.865 | 1.867 |
| DZT | 44.47 | 7.896 | 1.672 | 46.08 | 7.625 | 1.838 |
| P<0.05 | * | NS | NS | NS | ** | NS |

**Economic Analysis:** The data indicates that increasing planting population on Montauk sweet corn will not impact the marketability. This research was done using standard recommendations for fertilizer and herbicides. Insecticide and irrigation were not used at either site. Increased expenses for producing higher population plantings include higher seed and bag costs. Increased income was generated by harvesting higher marketable yields. Table 6 shows the potential economic gain from increasing population at $8.00 per bag (CT Weekly Ag Report, Aug. 2012).

Table 6. 2012 Griswold economic gain per acre

| Seeding Rate | Seed Cost | Ears Harvested | No. Bags Harvested | Gross | Increase[1] |
|---|---|---|---|---|---|
| 26136 | $183.30 | 21805 | 363 | $2904 | $0 |
| 29870 | $211.50 | 23469 | 391 | $3128 | $184.60 |
| 34848 | $246.75 | 26376 | 440 | $3520 | $521.75 |
| 41818 | $296.10 | 30410 | 507 | $4056 | $981.60 |

1. The increase is the difference between the gross of the standard population (26K) versus the increased population gross. That number is then reduced by the extra cost of seed and bags.

**Conclusions:** Increasing population of 'Montauk' sweet corn did decrease the weight, length and width of ears, which made it easier to pack and carry 5-dozen ear bags. However, the length and width were not reduced so much as to make the ear unmarketable. At both locations in both years ear length remained about 7.5 inches at the highest population. Quality (tip fill) decreased and the number of immature ears increased when the population was above 40,000 plants per acre. No extra fertilizer or pesticide was needed to produce the crop, only seed, bags and possibly labor. Additional profit should be attained whether wholesaling or retailing using high-density plantings of Montauk.

**Western Bean Cutworm: A New Corn Ear Pest in New England**

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**History.** Western bean cutworm (WBC, *Striacosta albicosta*) was historically found in the western Corn Belt, where it was a common pest of dry beans and corn. Starting in the year 2000, economic damage from this pest was found on corn in Iowa and Minnesota. Since then, this pest has continued to rapidly spread eastward, reaching Ohio in 2006 and the New England region from 2009 to present. Extensive damage to corn and dry beans in this region of expansion appears to be limited to more northern areas such as Michigan and Ontario, Canada. For example, most of Ohio and Pennsylvania have not yet encountered economic damage from this pest despite its presence in these areas for the past 6 years.

**Life Cycle and Damage.** The adults emerge in late June–early July after fully grown larvae overwinter inside soil chambers in the soil 3–8 inches deep. The adults are mostly dark brown and black, with three characteristic markings that distinguish them from other moths: (1) a white stripe on the top edge of the forewing, (2) a light brown/tan colored dot, and (3) a comma or crescent-shaped mark behind the dot. Peak flight of the adults usually occurs in mid-July, with adult flight ending by mid to late August. There is one generation per year. During the summer flights, adults mate, and females lay eggs on the uppermost portion of the flag leaf. Eggs are laid in unevenly distributed clusters of 5–200, but averaging about 50 per cluster, and hatch within 5–7 days, depending on temperature. Eggs first appear white, then tan and then a dark purple. Once eggs turn purple, hatching should occur within 24 hours. Larvae are tan in color, and can be identified by two broad stripes immediately behind the head. In pre-tassel corn, larvae will move to the whorl to feed on the flag leaf and un-emerged tassel. Once the tassel emerges, larvae then move to the ear, all the while feeding on corn pollen, leaf tissue, and silks. By the 4th instar, larvae will enter the ear through the tip, or by chewing through the side of the husk and feeding directly on the kernels. The presence of these burrows also makes the ear more prone to fungal and mycotoxin infection. Unlike corn earworm, WBCW are not cannibalistic, and multiple larvae may be found on corn ears. By the 6th or 7th instar, larvae emerge from the ear and fall to the ground to overwinter in soil chambers. Pupation occurs in May, immediately before adult emergence.

**Monitoring.**The easiest way to monitor the presence of this pest is by trapping the adult moths. Traps can be constructed out of empty milk jugs or by the use of bucket traps. For milk jug traps, four windows from an empty gallon milk jug are cut, and the jug is tied to a post at least 4 feet high. A bent paper clip is used to attach the lure to the inside lid of the milk jug and the cap is replaced to keep the lure in place. The bottom of the jug is filled with an 4:1; water:antifreeze solution, with a drop of dish soap added to break water surface tension. The bucket trap can be purchased at several IPM supply stores with instructions included. Pheromome lures usually last about 4 weeks, and the insecticidal strips for bucket traps need to be replaced after 6 weeks. Traps (either the milk jug or green bucket trap) are placed on the edge of a cornfield; one trap per field is sufficient. Traps should be inspected at least weekly from June 1 until mid-September. When the first adult is collected or when adults are collected on consecutive nights, scouting for eggs or larvae should begin.

To scout for eggs or larvae, choose at least 20 consecutive plants in 5 random locations and inspect the uppermost 3 leaves for eggs, as well as the silks for larvae if tassel has emerged. Be sure to inspect different areas of the field that may be in different growth stages, and especially in corn that has not tasselled. For field corn, if 5-8% or more of the plants inspected have eggs or larvae, consider treatment. For sweet corn, consider treatment if eggs or larvae are found on >4% of plants for the processing market or on >1% of plants for fresh-market.

**Treatment Considerations.** If infestations exceed threshold, many insecticides are available to adequately control WBC. However, as with any ear-burrowing Lepidopteran pest, timing is critical. Insecticide applications must occur after egg hatch, but before larvae enter the ear. If eggs have hatched, applications should be made after 95% of the field has tassel. If eggs have not hatched, monitor for the color change. Hatch will occur within 24–48 hours once eggs turn purple. To search for larval injury after it has occurred, growers can inspect corn for ears having feeding holes on the outside of the husks. WBC can be controlled with transgenic hybrids. However, only transgenic hybrids with the Cry1F or Vip3A gene will offer adequate to near-complete control of WBC. With any of these transgenics that offer WBC control, remember that the refuge (if not integrated) will require watching because those hybrids will not offer management of the insect. Some transgenic sweet corn varieties should provide control of WBC, as long as they contain either Cry1F or Vip3A. For example, Attribute II trait stack from Syngenta will control WBC because it includes Vip3A. Corn growers should check information provided in their seed guide for the presence of these two traits if controlling WBC is necessary.

Information is adapted from: Michel AP, Welty C, Hammond RB, Eisley JB. 2009. Western Bean Cutworm. Ohio State University Extension Fact Sheet: FC-ENT-40-09. Available at: http://ohioline.osu.edu/ent-fact/pdf/0040.pdf.

## Air Blast Sprayers for Sweet Corn - Calibration and Adjustment

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As stated on the pesticide label – the sprayer needs to be calibrated before you spray!

Proper calibration of air blast sprayer equipment is the only way to ensure spray applications are effective, efficient, and economical. Poor spray coverage is the primary cause of reduced spray product performance. Regular care and maintenance will ensure the sprayer is residue-free and serviceable when needed.

A sprayer should never be operated without first checking the calibration for the following reasons:

1. To determine the precise rate of material applied per acre.
2. To ensure each nozzle tip is operating at the manufacturer's specification.
3. To compensate for equipment changes, crop staging, and environmental conditions.

### Calibration Factors Affecting Application Rate

- Ground Speed

A uniform ground speed is necessary to maintain even spray application. The spray application per acre varies inversely with the ground speed of the sprayer. If the ground speed is doubled the application rate is cut in half and as the ground speed is reduced to half, the spray application is doubled. Rate controllers can only compensate for this within certain limits and can sometimes have a negative impact on spray quality.

- Nozzle Flow Rate

The flow rate through the nozzle varies with the tip size, the pressure applied, and the condition of the tip.

### Caution - When Spraying Sweet Corn Using an Air Blast Sprayer

Commercial sweet corn growers must use spray application equipment capable of depositing spray material at the ear zone. Drive rows are necessary for use of the air blast sprayer. Blocks between drive roads should not exceed 16 rows to allow sufficient spray coverage of the ear zone, if air blast sprayer is used from both sides. When raising taller growing sweet corn varieties, growers should consider having 12 row blocks so that better spray coverage of the ear zone can occur. Drive roads between blocks also aid in ease of harvest.

Growers need to apply insecticide with enough water. With air blast sprayers, growers need 75 to 100 gallons per acre to do the job correctly. With booms that extend out over the rows, growers can get away with as little as 50 gallons of water per acre and still get good control.

**Pre Air Blast Sprayer Calibration Instructions**

Prior to calibrating an air blast sprayer, please complete the following tasks:

1. Triple rinse tank and piping. Take special care to flush manifolds and nozzles.
2. Be careful if using pressure wash sprayers. Some say this forces water into sealed parts like bearings. You can use push brooms and hoses to scrub them off. Pay special attention to cleaning both sides of nozzles and around pump and filters.
3. Clean nozzles and record orifice and whirl disc sizes.
4. Flush out line to pressure gauge.
5. Clean filters, including tank filters, suction filters, final filters, and every screen behind nozzles.
6. Make sure all valves, diaphragms, and O-rings are in good condition and working properly.
7. Check tire pressures on both sprayer and tractor.
8. Make sure tachometer is working on tractor.
9. Fill sprayer ½ full with clean water.
10. Please have any operators or mechanics that work with the sprayer/tractor combination on hand for the sprayer calibration.
11. Have sprayer operator's manual on hand.

**Maintenance of the Sprayer**

The following practices will prolong the life of the sprayer:

1. Remove the nozzles and strainers; flush with clean water regularly.
2. Do not use any metal object when cleaning sprayer tips. Use a soft brush or try a can of compressed air (for cleaning keyboards).
3. Never apply corrosive fertilizer solutions through an air blast sprayer.
4. Remove and clean strainers daily or when products change on sequential applications, whichever comes first.

Nozzle wear occurs most rapidly when wettable powders, flowables, or dispersible granules are applied, especially at high nozzle pressures. Under these situations, the tips and cores on the sprayer should be manufactured from hard, wear resistant materials. The abrasion resistant nozzle components cost more initially, but in the long term are quite cost effective.

**Calibration Notes**

Recording your sprayer calibration calculations for future use is important. By having a record, you can compare your sprayer calibration calculations from calibration to calibration. This information can be useful the next time you check the calibration. This recordkeeping is also due-diligence and is important to have on hand if ever a question arises about product residue, pesticide drift, or any other spray complaint.

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# Air-Blast Sprayer Calibration Worksheet

***Retain the following information for your records:***

Date _________________.

Farm_________________________ Operator ____________________ Phone ________________.

Address_______________________ Town __________________ State ______ Zipcode __________.

Tractor _______________________ Sprayer________________

Tractor Gear __________________ Tank______________gallons

Tractor RPM___________________ Pump Pressure________PSI

Measured Distance_______ feet

Time in seconds (down) __________

Time in seconds (back) __________

Average Time in seconds _________ ***MPH*** *= Miles per Hour*

Miles per Hour = Distance in Feet x 60 / Time in Seconds x 88 = ( ______ Feet) x 60 / ( ______ Seconds) X 88 = _________ = _________ MPH

*For Orchards:*

Block (#____________) Tree Height _______ ft. Tree Width _______ ft. Row Width __________ ft.

*For Vegetable or Other Crops Sprayed:*

Crop:_________________________

Block (#____________) Spray Swath Width ___________ft

Linear Feet of Row per Acre = 43,560 / Row Width Or Spray Swath Width = 43,560 / ( ) = (_____) Feet per Acre

Speed in Feet per Minute = MPH **X** 88 = (_____) MPH **X** 88 = (_______) Feet per Minute

| Nozzle Output for Air-Blast Sprayer - To determine the left versus right side, look at the sprayer from behind | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nozzle Output - Left | | | | | Nozzle Output - Right | | | | |
| Nozzle # | Tip Size # | Disc Core # | Fluid Ounces Per Minute | Gallons Per Minute | Nozzle # | Tip Size # | Disc Core # | Fluid Ounces Per Minute | Gallons Per Minute |
| L-10 | | | | | R-10 | | | | |
| L-09 | | | | | R-09 | | | | |
| L-08 | | | | | R-08 | | | | |
| L-07 | | | | | R-07 | | | | |
| L-06 | | | | | R-06 | | | | |
| L-05 | | | | | R-05 | | | | |
| L-04 | | | | | R-04 | | | | |
| L-03 | | | | | R-03 | | | | |
| L-02 | | | | | R-02 | | | | |
| L-01 | | | | | R-01 | | | | |
| Total Left Side Manifold Output in GPM | | | | | Total Right Side Manifold Output in GPM | | | | |
| Total Output for Sprayer in GPM | | | | | | | | | |

***GPM** = Gallons per Minutes* ***GPA** = Gallons per Acre* ***MPA** = Minutes per Acre or Minutes/Acre*

All Nozzles Output = (_______) GPM

Block (#_______) Minutes/Acre = Linear Feet Row per Acre / Feet per Minute = (__________) / (          ) = (________) Minutes/Acre

Output - Gallons Per Acre = GPM **X** MPA = (_______) GPM **X** (_______) MPA = (_______)GPA

**NOTES:**

*George Hamilton, Extension Educator, Agricultural Resources, Hillsborough County* *July 15, 2013*

**Update on late blight management: can resistant varieties play a role?**

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Late blight has developed on tomato in the Northeastern USA every season since 2009. Change in occurrence of this destructive disease is at least partly due to the fact there are new genotypes (strains) of the pathogen in the USA. Many are more aggressive on tomato and more tolerant of warm temperatures than genotypes like US-1 and US-8 that previously were dominant.

Resistant varieties can indeed play an important role in managing late blight in tomato. Several have proven very effective against the pathogen genotype that has been the dominant one in the northeast recently, which is US-23. Resistant varieties are a valuable tool for managing any plant disease, but they are especially valuable for late blight, because this disease can be very difficult to control with fungicide applications started after onset and it cannot be 'tolerated'. Left unmanaged, late blight is much more likely than other diseases to completely destroy a crop and also to have devastating impact on other tomato plantings in a region due to the quantity of pathogen spores that can be produced and easily dispersed by wind.

*Evaluations of resistant varieties* are being conducted each year on Long Island, NY, as well as elsewhere. Very good resistance of foliar and fruit symptoms of late blight was exhibited by all tomato varieties and experimental hybrids evaluated that have the *Ph2* and/or *Ph3* major genes for resistance, plus some with undetermined resistance, which were Plum Regal (homozygous Ph3), JTO-545 (heterozygous Ph3), Legend OP (Ph2), Matt's Wild Cherry (undetermined resistance, possibly Ph3), Jasper (undetermined resistance, likely Ph2 and/or Ph3), Iron Lady (homozygous Ph2 + Ph3), and Defiant PHR, Mountain Magic, Mountain Merit, and experimentals from the Cornell University Dept of Plant Breeding (all heterozygous Ph2 + Ph3). Heterozygous means the hybrid has one copy of the resistance gene; homozygous means it has a copy from both parents which is expected to impart a higher level of resistance. Legend, the only entry with just the Ph2 gene, was numerically, but not significantly, more severely affected by late blight than the other resistant entries in 2012 (2013 data has not been analyzed yet). Tomatoes with just the Ph3 gene were more severely affected by late blight than the resistant entries that also had the Ph2 gene.

Late blight became severe in New Yorker (Ph1). Severity of symptoms was similar to the varieties without major resistance genes, which were Mountain Fresh Plus, Juliet and Brandywine. In addition to being ineffective against genotype US-23, the Ph1 gene is also not effective for other genotypes of the pathogen that have occurred in recent years. Thus varieties with only this gene are not recommended.

In conclusion, best suppression of the late blight US-23 genotype was achieved with tomato possessing both the Ph2 and Ph3 resistance genes. Only a few fruit with symptoms of late blight were observed on these entries. Mountain Magic, Jasper, and Matt's Wild Cherry were the three resistant varieties receiving the highest overall rating in the 10 evaluations conducted by public groups in 2012.

*Resistant varieties need to be part of an integrated program for managing late blight.*

Being ready is an important aspect of successfully managing late blight in tomato and potato. This entails not only understanding in advance how to manage this destructive disease, but also understanding that it can start to develop in a crop at any time, as well as understanding the importance of reporting occurrences and managing all outbreaks of this highly contagious, community disease. The pathogen population has changed in the USA, which partly explains why late blight has been occurring more often recently. Preparing is critical because late blight is a top contender for most difficult disease to manage after detection.

Reporting occurrences of late blight is very important. This is a community disease requiring community action based on knowledge of outbreaks to avoid major losses. There is also a need to know where late blight occurs throughout the growing season in order to study movement of the pathogen and develop a predictive system to enable growers to be more informed about potential outbreaks in the future. This is a goal of the national late blight project. Thus it is important to report all occurrences. Success of this late blight project is dependent on growers reporting.

Submitting samples is also very important. Scientists involved with the national USAblight project can in a day determine the genotype of the pathogen on submitted plant tissue. This is useful for identifying the source of the pathogen. And it is very valuable to know if the strain present is sensitive to mefenoxam, the active ingredient in Ridomil, as it continues to be the most effective fungicide for late blight. US-22 and US-23 genotypes are sensitive. US-8 genotype is completely resistant. Samples are needed from multiple farms affected in a region to determine if more than one strain is present. It is very valuable to know when multiple strains are present in a region, especially if they differ in sensitivity to mefenoxam or in mating type, which is the pathogen equivalent of gender. There are now strains of both mating type in the USA. If they grow together the pathogen will reproduce sexually, creating new strains, and, even more importantly, producing a type of spore (oospore) that will enable the pathogen to survive over winter in soil in the absence of living plant tissue, allowing late blight to become a more routinely occurring disease. Therefore, finding both mating types together warrants more aggressive management.

Educating gardeners about late blight is important because a small, unmanaged outbreak can lead to a major epidemic. This is likely what happened in 2009 and on Long Island in 2011. A trifold brochure has been prepared with pictures of symptoms and information about the importance of late blight plus management practices geared primarily for gardeners. It is available for growers to provide to their customers who garden. Call 631-727-3595 (or email mtm3@cornell.edu) to request copies. Or direct gardeners to http://www.usablight.org/node/44 and http://www.hort.cornell.edu/lateblight.

**Late Blight Management Steps for 2014:**

1. Destroy potato volunteers and cull piles.
2. Use treated, certified seed pieces.
3. Select less susceptible potato varieties and resistant tomato varieties when possible.
4. A broad-spectrum fungicide (e.g. chlorothalonil for conventional production and copper for organic crops) applied before disease onset will protect crops.
5. Monitor occurrences at http://usablight.org/. Sign up to receive alerts.
6. Know symptoms. Inspect all potato and tomato crops weekly from emergence or transplanting. Plants in high tunnels and greenhouses are not protected. The first occurrence of late blight in 2010 in the northeast was in a high tunnel in Maryland in late April.
7. Submit any suspect symptoms (bagged) for diagnosis promptly to a Diagnostic Laboratory or an Extension Specialist.
8. Notify neighboring growers when late blight is confirmed on your farm so they can protect their crops.
9. Apply fungicides for late blight when confirmed on your farm or nearby. Alternate among fungicides in different chemical groups (as indicated by FRAC Code)(see list below) and tank mix with a protectant fungicide to manage resistance.
10. Use the Late Blight Decision Support System to decide when to apply fungicides (it is under the 'Cornell DSS' tab at the USAblight web site).
11. Promptly destroy tomato plants after harvest or when late blight becomes too severe to manage. Options include applying a fast-acting herbicide like diquat, or mowing or disking preferably on a sunny day when foliage is dry.
12. With potato crops affected by late blight, vine kill early before there are many symptoms on main stems (the most important source of inoculum for tuber blight) and before heavy rain is forecast to avoid an opportunity for spores to be washed down to tubers. Harvest at least two weeks after vine kill and before soil temperatures drop below 54 F. Avoid bruising and skinning while harvesting. Best to market after inspecting tubers for blight. If stored, cool down quickly, provide good ventilation in storage, and inspect routinely.

*Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Before purchase, make sure product is registered in your state and approved by your certifier for organic production. In some states products that are exempt from EPA registration because of their ingredients, such as Sporatec, do not need to be registered in the state (this is the case in New York but not in Maine). Any reference to commercial products, trade or brand names is for information only; no endorsement is intended. There is limited data from replicated experiments on efficacy for late blight of products approved for organic production other than copper.*

**Conventional Fungicides with Targeted Activity for Late Blight** (listed alphabetically):

**Curzate** 60DF (FRAC Group 27). Active ingredient is Cymoxanil. EPA Reg No. 352-592. 3.2-5 ounces per acre (3.2 ounces for potatoes). 5 oz on 5-day interval when late blight present. 30 oz/A seasonal max. 12 h REI. 3 d PHI. Must be tank-mixed with a protectant fungicide. Curzate has some kickback activity when it is cool (maximum of about two days), but little residual activity (about five days).

**Forum** (Group 40). Dimethomorph. EPA Reg No. 241-427. 6 fluid ounces. 30 fl oz/A seasonal max. 2 consecutive spray max. 12 h REI. 4 d PHI. Must be applied with another fungicide.

**Gavel** (Group 22). Zoxamide + mancozeb (protectant fungicide). EPA Reg No. 62719-441. 1.5-2 pounds. 16 lb or 8 application seasonal max. 48 h REI. 5 d PHI tomato; 3 d PHI for potato (14 d in some states). Latron surfactant recommended.

**Presidio** (Group 43). Flupicolide. EPA Reg No. 59639-140. 3-4 fl oz for tomatoes. 12 fl oz/A seasonal max. 2 consecutive spray max. 12 h REI. 2 d PHI. Current label has a rotational restriction of 18-mo for non-labeled crops which includes sweet corn.

**Previcur Flex** (Group 28). Propamocarb hydrochloride. EPA Reg No. 264-678. 0.7-1.5 pint (1.2 pints max for potatoes). 7.5 pts/A seasonal max for tomatoes; 6 pts/A for potatoes. 12 h REI. 5 d PHI for tomato; 14 d PHI for potato. Previcur Flex has some systemic activity and thus can protect stems and new growth.

**Ranman** (Group 21). Cyazofamid. EPA Reg No. 71512-3-279. 1.4–2.75 fluid ounces (2.1-2.75 for tomato). 16.5 fl oz or 6 application seasonal max for tomatoes; 27.5 fl oz or 10 applications for potatoes. 12 h REI. 0 d PHI for tomatoes; 7 d for potatoes. Use an organosilicone and/or non-ionic surfactant (see label for directions).

**Reason** (Group 11). Fenamidone. EPA Reg No. 264-695. 5.5 to 8.2 fluid ounces. Alternate with other fungicides; do not make consecutive applications. 24.6 fl oz/A seasonal max. 12 h REI. 14 d PHI.

**Revus** (Group 40). Mandipropamid. EPA Reg No. 100-1254. 5.5 to 8 fluid ounces. 2 consecutive spray max. 32 fl oz/A seasonal max. 12 h REI. 1 d PHI for tomato; 14 d PHI for potato. Revus has some kickback activity.

**Ridomil Gold Bravo** (Group 4) or OLF. Mefenoxam + chlorothalonil (protectant fungicide). EPA Reg No. 100-1221. ONLY recommended for sensitive pathogen strains. 2.5 pt/A. 48 h REI. 5 d PHI for tomato; 14 d PHI for potato. Seasonal max use for tomato (potato): 15 (11.25) lbs. a.i./A chlorothalonil and 0.5 (0.4) lb. a.i./A foliar-applied mefenoxam.

**Zampro** (Group 40 and 45). Dimethomorph + Ametoctradin. EPA Reg No. 7969-302. 14 fluid ounces for tomato; 11-14 for potato. 42 fl oz/A seasonal max (3 applications). 2 consecutive spray max. 12 h REI. 4 d PHI. Including a spreading/penetrating adjuvant is recommended.

**Fungicides for Organic Production (all OMRI-listed) and Labeled for Late Blight.** These are recommended used in combination or alternation with copper fungicide:

**Actinovate AG**. *Streptomyces lydicus* strain WYEC 108. EPA Reg. No. 73314-1. Efficacy documented in an experiment conducted in Florida.

**Regalia**. Extract of *Reynoutria sachalinensis*. Boosts plants' natural defense mechanisms against certain fungal and bacterial diseases. EPA Reg. No. 84059-2.

**DoubleNickel 55.** 25% *Bacillus amyloliquefaciens* strain D747. EPA Reg. No. 70051-108.

**Sonata**. 1.38% *Bacillus pumilus* strain QST 2808. EPA Reg. No. 69592-13.

**Serenade Max**. 14.6% *Bacillus subtilis* strain QST 713. EPA Reg. No. 69592-11

**Companion biological fungicide**. 0.03% *Bacillus subtilis* strain GB03. EPA Reg. No. 71065-3.

**Sporatec AG**. 18% rosemary oil, 10% clove oil, + 10% thyme oil. Exempt from registration.

**OxiDate**. 27% hydrogen dioxide. EPA Reg. No. 70299-2.

**Panel Discussion “Tomato varieties that taste good, grow well, and sell!”**

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Late blight and other fungal diseases present a management challenge for tomato growers in the Northeast. While fungicides exist to manage those diseases, some growers prefer to use them sparingly due to costs, farm philosophy and/or consumer preference. Because of these issues there is a growing interest in disease resistant tomato varieties.

Seven varieties of tomatoes marketed as late blight resistant were compared to one industry standard, non-resistant variety in a replicated field tomato trial in the summer of 2013. As growing conditions vary significantly across New Hampshire, the trial was carried out in three locations simultaneously; Durham (zone 5b), Ossipee (zone 5a), and North Haverhill (zone 4b).

All seedlings were grown in a greenhouse in North Haverhill and transported to the research sites for outplanting the first week of June in four replications with five plants per plot. A basket weave system was used for trellising. Harvest started in late July and continued until mid-September. Data was collected on yield, quality, flavor and resistance to disease. Data analysis was still underway at the time this article was written, what follows is based on results in the North Haverhill site only.

**Plum Regal**

- 4.8 oz red plums
- Medium yields
- Deep red flesh
- Good flavor
- Variable skin color
- Late yields

**Mountain Magic**

- 1.8 oz saladette
- Good yields
- Very uniform
- Low percentage of culls
- Very sweet

**Yellow Pear**

- 0.5 oz yellow, pear shaped cherries
- Low yields
- Low percentage of culls
- Variable color and shape, easily scarred

- Vigorous growth habit
- Good flavor

**Jasper**
- 0.3 oz red cherries
- Low yields
- High percentage of culls
- Very prone to cracking
- Extremely vigorous growth habit
- Good flavor
- Early yields

**Defiant**
- 5.9 oz red beefsteaks
- High yields
- High percentage of culls
- Good flavor

**Legend**
- 7.2 oz red beefsteaks
- Good yields
- Unusual flavor

**Iron Lady**
- 6.1 oz red beefsteaks
- Good yields
- Late yielding
- Firm fruit
- Good flavor

**Celebrity**
- 8.6 oz red beefsteaks
- Good yields
- Good flavor

**Designing an Effective Fungicide Program (Organic and Conventional) to Manage Tomato Diseases**

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While fungicide choice is important, there is a lot more to designing an effective fungicide program than selecting the most efficacious product!

The first step in designing an effective fungicide program is making a list of the diseases that have occurred in previous years. Try to identify any unknown diseases. This is important because the most effective fungicides, especially among conventional products, often have targeted activity, which may be limited to one disease. Also, some diseases (and not just those caused by viruses) plus disorders (which can be mistaken for a disease) are not affected by any fungicide.

Application timing can be at least as important as the products used. A program will be more effective when started as soon as first symptoms are seen or before. This is because very few fungicides (and only conventional ones) have curative (kickback) activity, and curative activity is effective only on recent infections. It typically takes about a week from infection until symptoms are visible for most diseases caused by fungi and bacteria. At this point the pathogen is established and not only cannot be killed by the fungicide, but will continue producing more inoculum for additional infections. Most fungicides act on pathogens to prevent infection. Actigard, phosphorous acids, Regalia, Companion and other fungicides that activate the plant's defenses (systemic acquired resistance = SAR) need to be applied starting before disease onset to be effective. Some diseases, in particular late blight and those caused by bacteria, are notoriously difficult to suppress on susceptible varieties without a preventive program.

Appropriate timing of successive applications in a fungicide program is also important. Calendar-based scheduling (e.g. 7-day spray interval) often is used. However, it is impact of environmental conditions on fungicide and the pathogen that determines when another application is needed. Rain (and irrigation) can remove some residue from plant tissue, more so with contact products than those that are mobile and move into plant tissue. Two inches of water is considered the amount that will remove residue of most contact fungicides. Fungicide formulations often include spreaders and stickers to minimize wash-off, or penetrants to facilitate uptake of mobile products. Sometimes the manufacturer of a fungicide will recommend that an adjuvant be used to improve control. This will be stated in the use directions.

Environmental conditions also affect the pathogen's activity. Most fungal and bacterial pathogens need free moisture on leaves lasting a long enough period of time that they can complete the infection period. Some can infect when humidity is high (typically above 90%). The amount of time needed depends on the pathogen and on the temperature. The optimum temperature for development varies among pathogens. Powdery mildew fungi, including the one that is a pathogen on tomato, are exceptions and prefer dry conditions. Forecasting programs have been developed for some diseases, including early blight, Septoria leaf spot, and anthracnose (TOM-CAST) and late blight (Cornell Decision Support System) of tomato. These programs can be run for a particular crop using data from a near-by weather station that is part of the NEWA (Network for Environment and Weather Applications). They are accessible through http://newa.cornell.edu/ under 'Crop Pages'. When a fungicide application is warranted is determined based on susceptibility of the variety and temperature plus moisture data since the last application (or since planting for the first application) and forecast conditions.

Environmental conditions during and after an application can also impact fungicide efficacy. If leaves are wet from dew or rain when an application is made, some product may run off leaves. Some product can also be lost if rain or dew occurs before the spray residue has completely dried, necessitating making another application soon to maintain control. Products differ in rainfastness, which is the time needed for a pesticide to dry sufficiently that rain or irrigation will not affect efficacy. The rainfastness of a product often is included on the label or in company information posted on the web. This information has been posted for several products at http://edis.ifas.ufl.edu/pi238

The equipment used to make an application also can impact the program efficacy. Nozzles differ in their suitability for applying fungicides compared to other pesticides. Information on this is at http://www.teejet.com/media/40076/users%20guide%20final%28low%29.pdf Having drop nozzles directed at each side of the plant as well as a nozzle directed at the top to the plant will improve coverage with trellised tomatoes. Drop nozzles are especially important for maximizing disease control because many diseases start to develop on leaves that are low in the canopy and also inside the lower canopy. Mobile fungicides cannot move from where deposited on upper leaves to leaves low in the canopy. Sprayer pressure is also important. Large droplets are formed when pressure is low. These are more likely to run off leaves than small droplets, and large droplets provide less coverage than the same amount of fungicide solution in several small droplets. Recommended pressure to use is around 60 psi, varying a bit with the nozzle type. When very high pressure is used there will be more small droplets prone to drift. When spraying several plantings, start with the youngest or the one with least symptoms. Airblast sprayers are not recommended when bacterial pathogens are present because the force of the spray can move bacteria between rows and it can cause small wounds that serve as infection sites for bacteria.

Being prepared before the growing season gets underway is also important because it minimizes response time. This includes de-winterizing the sprayer, making sure it is fully functional, replacing old nozzles, and calibrating the sprayer. It also includes deciding what products will be used, calculating the amount needed for each application, and identifying a source. Purchasing products in advance also facilitates responding immediately to disease detection.

An important component of an effective fungicide program is resistance management. This is because most fungicides with targeted activity are prone to resistance development because they have single site mode of action. Additionally, resistance management needs to always be implemented, starting at first use of the fungicide, because the primary goal is to delay resistance development rather than to manage resistant pathogen strains after they have been detected. First determine what pathogens have already developed resistance and to which fungicides. Some types of fungicides labeled for a disease may no longer be recommended for use in the northeast, or recommended used on a limited basis, because of resistance. General recommendations for managing fungicide resistance are to use products at risk for resistance development in alternation based on FRAC Code and tank-mixed with a contact, protectant fungicide that has low risk.

To achieve the full potential of a fungicide program, it needs to be implemented as part of an integrated program with cultural practices. Fungicides should not be relied on as the sole management practice especially under severe disease pressure. Cultural practices for diseases of tomato include rotation, selecting resistant varieties, using seed tested and treated for seed-borne pathogens, disinfecting used trays, stakes, and other planting materials, mulching, trellising, and using drip irrigation. Also select planting site with good air movement and soil that drains well. Plant parallel to the prevailing wind direction. Destroy infested crop debris after harvest and incorporate into soil to hasten decomposition.

**Conventional and organic fungicides and bactericides for diseases affecting tomatoes in the northeastern USA.** Products are listed by disease beginning with products applied before planting and those affecting seedlings during transplant production. Products approved for organic production (OMRI-listed) are designated. They could be used as the protectant fungicide in a conventional fungicide program. OLP = other labeled product. Several conventional fungicides are not permitted used in greenhouses primarily because of concerns of fungicide resistance development in a contained pathogen population. Under current regulation, a product can be used in a greenhouse if the label does not state that greenhouse use is prohibited.

<u>Diseases managed before planting</u>:

White mold. Apply Contans (organic) to soil at planting or transplanting. Treatment in the fall and again in the spring may improve control.

<u>Diseases affecting seedlings during transplant production</u>:

Bacterial diseases. Agri-mycin. Copper tank-mixed with mancozeb.

ORGANIC: copper, DoubleNickel, Organocide, Regalia, Cease or Serenade Optimum* (Cease is a greenhouse product), Sporatec AG, OxiDate

Damping-off. Conventional fungicides with targeted activity for *Pythium*: Previcur Flex - apply as a directed spray to lower stems and soil. Ranman – apply as a drench to seeding tray anytime from seeding to 1 week before transplanting.

ORGANIC: several biopesticides are labeled for applying to the seeding mix, including Actinovate, Bio-Tam, Double Nickel 55, Mycostop, Prestop, RootShield Granules, Serenade Soil, and Tenet.

Gray mold (Botrytis). Decree (FRAC Code 17); labeled for use with another labeled fungicide. Scala (9) can be applied in a well-ventilated plastic tunnel or glass house; ventilate for at least 2 hours after application.

ORGANIC: copper, Actinovate, DoubleNickel, MilStop, Regalia, Serenade Optimum*, Sporatec AG, Trilogy, OxiDate

<u>Root rots in the field</u>. Note that Previcur Flex and Ranman are labeled for use in the greenhouse but not in the field.

Ridomil Gold SL or OLP - apply to soil at planting, then inject into drip irrigation 4 to 6 weeks later. Targeted activity for *Pythium* and *Phytophthora*.

ORGANIC: biopesticides listed above for damping-off are also labeled for application to soil in field. Additional products: Regalia.

Foliar and fruit diseases. When a preventive application schedule is used for a conventionally-produced crop, protectant fungicides are recommended until diseases are detected, then switch to a targeted fungicide for the specific disease(s) developing. Alternate among products in different FRAC Groups is needed for managing resistance and often is a label restriction, also tank-mix with protectant fungicides.

Protectant fungicides. copper, chlorothalonil, mancozeb, ziram, or an organic product.

Anthracnose. FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), Flint, or Tanos (27)], Catamaran (33+M5), Inspire Super (3 + 9), Revus Top (3 + 40).

ORGANIC: copper, Actinovate, MilStop, Trilogy, OxiDate

Bacterial diseases (speck and spot). Actigard, copper tank-mixed with mancozeb. Tanos is labeled for suppression used with copper plus mancozeb. Resistance to copper is common.

ORGANIC: copper, DoubleNickel, Organocide, Regalia, Serenade Optimum*, Sporatec AG, OxiDate

Bacterial canker. copper

Buckeye (Phytophthora) fruit rot. Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Revus (40) or Revus Top (3 + 40), Tanos or Reason (11), Ridomil Gold Bravo or OLP (3), Ranman (21), Aliette (33), Gavel (22), Presidio (43). There are pathogen strains resistance to Ridomil.
ORGANIC: Serenade Optimum*

Botrytis gray mold. Endura (7), Inspire Super (3 + 9), Scala (9), Switch (9 + 12) (note that these 3 are in the same FRAC group, Cabrio (11) (suppresses). Uncommon in field-grown crops.
ORGANIC: copper, Actinovate, DoubleNickel, MilStop, Regalia, Serenade Optimum*, Sporatec AG, Trilogy, OxiDate

Early blight. Endura (7), Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Revus (40) or Revus Top (3 + 40), Previcur Flex (28), Catamaran (33+M5), FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), Tanos (27), Cabrio, Flint, or Reason]. Pathogen strains resistant to QoI fungicides (11) and strains with reduced sensitivity to chlorothalonil have been detected in a few locations in the US where these products are used intensively.
ORGANIC: copper, Actinovate, DoubleNickel, Regalia, Serenade Optimum or OLP*, Sonata, Sporatec AG, Trilogy, OxiDate

Late blight. Curzate or Tanos (both have same active ingredient in FRAC Group 27), Presidio (43), Previcur Flex (28), Ranman (21), Reason (11), Revus (40), Gavel (22), and Forum (40). These need to be tank-mixed with a protectant fungicide, except for Gavel, which contains mancozeb. Note that applying chlorothalonil weekly starting before disease onset has provided good control in fungicide efficacy experiments. This disease is extremely difficult to control with fungicide applications started after detection. Curzate and Tanos have good curative activity but short residual activity, thus another fungicide will be needed about 3-5 days after application. Previcur Flex has good systemic activity and thus protects stems and new growth. Ridomil Gold Bravo (or OLP) is very effective for sensitive pathogen strains like US-23, which has been the main one detected recently in the Northeastern USA. Strain identification can now be done in 1-2 days.
ORGANIC: copper, Actinovate, DoubleNickel, Regalia, Serenade Optimum*, Sonata, Sporatec AG, OxiDate

Leaf mold (some labels only have pathogen name, *Cladosporiuma* or *Fulvia*). Tanos, protectant fungicides. Uncommon in field-grown crops.
ORGANIC: copper, OxiDate

Powdery mildew. Rally (3), Quadris, Cabrio, or Flint (all 11).
ORGANIC: copper, sulfur, Actinovate, Kaligreen, MilStop, Organic JMS Stylet-oil, Organocide, Regalia, Serenade ASO, Sonata, Sporatec AG, Trilogy, OxiDate

Septoria leaf spot. FRAC Group 11 fungicide [Quadris, Quadris Opti (also M5), Quadris Top (3), Tanos (27), Cabrio, Flint, or Reason], Inspire Super (3 + 9), Scala (9), Switch (9 + 12), Revus Top (3 + 40), Previcur Flex (28), Tanos (27), Catamaran (33+M5)
ORGANIC: copper, Organocide

* Serenade Optimum is a new formulation.

*Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Before purchase, make sure product is registered in your state and approved by your certifier for organic production. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.*

**Marketing and Social Media at Kilpatrick Family Farm**

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Kilpatrick Family Farm is a mixed vegetable, fruit and poultry farm located in Middle Granville, NY zone 4b. We sell majority retail through a 200 member CSA as well as several strong Farmers markets in Saratoga Springs and Glens Falls, NY. We also sell limited wholesale through Co-ops, restaurants, and to other CSA's. The farm is approximately 500 acres of owned, rented and leased land, 40 tillable, 100 pasture, and the balance woodlot and scrub. We plant between 12-14 acres of vegetables and fruit every year.

Marketing is how we find new customers, and let our current customers find out about our products. On most farms, it is one of the last things thought about but one of the most important things the farm does. If you can't sell a product why grow it? It ends up as really expensive compost.

As 90 % of our business is retail is it important for us to be able to connect with our customers. We use our website as a portal for customers to interact, sign up for products (csa, newsletters, bulk produce orders, and find information out about our farm and different markets. We use social media to connect with them in mediums that they are already familiar with and that they access on a daily basis. We use our email newsletter as a voice into our customers mailboxes full of news, recipes, pictures, and more about the farm.

A good website is usually the most expensive part of an online presence. It usually takes the most time, content, and effort to keep up to date. However, it is the basis for a good web strategy and where most of your content will end up being linked or sourced from. Basics of a good web site are clean, easy to navigate pages, information about the farm, hours of operation, and contact information. As well as picture galleries, recipes, and links to social media.

Social media is constantly changing and adapting as new startups build a platform, find a way to make money, and then goes IPO (initial Public offering, or when the company sells shares). For example, Facebook started monetizing through ads and then sponsored posts. It has become that if you want a post to show up to all your customers you now have to buy that privilege. Basically, nothing is free.

Web ads can be a very good place to advertise, most online advertising allows you to segment the audience and pick only those who are interested in what you are selling. For example, you can target females who are between 25-35, in a relationship, that like organic produce and live in your pre-specified zip code. Most online advertising is sold per click, not per impression like radio or newspaper ads, thus much more effective (and expensive) per unit.

An email newsletter can also be an important part of a media strategy. It is a way to send information to a customer easily, cheaply, and content rich. An email newsletter can contain information about the farm, events, sales, promotions or even video of last year's haunted hayride. Email newsletters also allow you to track read rate and if customers are using the newsletters features, providing immediate feedback of marketing efforts.

With the crazy world of different options out there one big word of advice would be to start small. Give the job of setting it up to the 20-somethings that work for you, just make sure they give you a quick tutorial as well as the passwords to access the site. Or, there are many professionals that charge a relatively cheap rate to set up the systems for you and then teach you to manage it.

**Lessons Learned Offering Spring, Summer, and Winter CSA Shares**

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Jericho Settlers Farm has been offering a year round CSA program since 2010. We divide the year into three seasons: Spring, Summer, and Winter. The Spring and Winter seasons each consist of eight pickups that occur every other week, with the winter season running from mid October to early February and the spring season from late February through May. The summer season runs weekly from mid June through mid October for 17 weeks. We offer vegetable, meat, and "settlervore" (eggs, bread, cheese, plus) shares from which members can choose to sign up for any combination of shares. Year round members receive discounts for signing up for the same type of share for all three seasons. Annual memberships start with the spring share and we open up signup in January each year. Members can sign up on-line and pay via Paypal or mail us a check. Both full payment and quarterly payment options are available and we arrange other payment plans upon request.

In a given year our membership represents 300 families on average. Our membership per season is 150 shares (spring and winter) and 200 shares for the summer season. We began offering year round membership discounts in 2011 and twenty members signed up. Now in 2013 we have thirty-five year round members, or about 10% of our total member population. Our goal is to have 75 year round members by 2016.

Offering a year round CSA program obviously has some disadvantages if you want to take the winters off from farming, but since we are also livestock farmers that is not something we are going to do anyway, so keeping our vegetable operation going year round makes sense for us. It has numerous advantages:

MARKETING

- It helps to maintain customer loyalty – our members don't have to find another farm, farmers market, or store to provide their local food in the winter and spring
- Our marketing efforts are less per product sold: we can sell more to our current customers, rather than having to recruit more new customers
- We do not have to compete as aggressively in a somewhat saturated summer CSA market

EMPLOYEES

- We have year round work for our employees, allowing for better employee retention and thus gained production efficiencies in not having to retrain a new crew each year
- With this trained crew we can more effectively schedule family vacations, because we have the confidence and strong working relationship with our crew to know they can run the farm in our absence (hence we don't necessarily need "winters off")

FINANCES

- A year round CSA program provides year round cash flow
- And it is a solid retail market during the "off seasons".

There are a few areas we pay close attention to in order to keep our year round program successful.

- We focus on keeping share composition exciting during the deep winter. For us this means a commitment to winter growing and providing "fresh" green vegetables all winter long, as well as freezing the summer favorites like tomatoes and corn.
- We have a comfortable, accessible winter pickup location: the art gallery on premises at the farm.
- The every other week pickup schedule in winter suits both our needs and our customers' needs: it gives a less intense schedule than summer, and since the produce is less perishable than most summer crops the members can receive enough for two weeks worth of eating without it spoiling, which means their pickup commitment is also less intense.
- During the winter we switch our "on farm" pickup day from a Monday to a Saturday, which allows members to pick up during daylight and keeps the pickup relaxed and enjoyable. We offer a "bag it up" service for late pickups.
- We provide recipes via e-newsletter for every pickup and make sure they are appropriate to the season and focused on simple, fast food prep ideas that bring out the best in the winter vegetables without enslaving members to their kitchens.

# Managing a Large Scale CSA with Multiple Locations

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**Farm Background:**
Red Fire Farm developed from a market garden started by farmer Ryan Voiland when he was a teenager starting in the early 1990's. Ryan farmed mostly on rented acreage until buying the farms first property in 2001. In the early years the business was focused mostly on a roadside farm stand located in Montague MA in the front yard of Ryan's parents home, as well as a local farmers market and some limited direct to store wholesale to stores & restaurants in Western MA. In 2001 now farming on newly purchased property in Granby, the farm added a CSA share offering, starting with about 100 shares that season. Share #'s have grown over the years, especially after we started doing off farm distributions in the greater Boston area.

**Farm Land & Facilities:**
Much of the land we farm in Granby MA is land that the farm rents. Most of these fields are not protected by APR, and out rental agreement is season to season. Unable to negotiate any long-term land tenure on these fields, we decided in 2009 to search for additional farmland to purchase. There being no quality acreage in the vicinity of our Granby location, we were able to find two adjacent properties with 45 acres of cropland plus 10,000 square feet of greenhouse space, and office building, a farmhouse and several barns located in Montague MA near the Connecticut River. We decided to take out an additional mortgage and purchase these properties in 2009 and 2010. We then began the three-year process of transitioning the land to certified organic (several years of cover crops). Our plan was to continue the Granby location, but to move the major office and produce packing and distribution functions to the Montague location. Soon after closing on the Montague property we initiated a remodel and addition onto the large barn in order to make it suitable for produce packing. We moved our office and packing starting in January of 2012, so we have had our headquarters in Montague for about two years.

**Montague Packing Barn:**
We rebuilt the floors so they are all at one level, added a matching five truck loading dock, made four separate cooler chambers (geothermal cooled) that can accommodate up to about 100 pallets of produce for winter storage, added insulation to the walls of the produce wash room, added a drainage field for the muddy wash water. The remodel cost about $300,000 over two years.

**Current Land Situation:**
Granby- We own about 15 acres of good cropland in Granby that is immediately adjacent to our Granby Farm Stand / CSA location. We use this acreage almost exclusively for CSA member pick your own crops. There are about 200 members per week who pick up their shares at this location, and we direct all of our Boston and Springfield area members to go to this location for their Pick Your Own crop picking.

We also still rent around 70 additional acres in Granby (despite not having long term land tenure on much of this). We plant around 30 acres of this land per year focusing almost exclusively on Salad Greens, Greenhouse Tomatoes, and Bulk harvested root / storage vegetables.
Montague- Upon moving to Montague, we saw the need for more acreage in addition to the 45 we purchased. Over the last few years we arranged to lease additional fields in the Montague and Sunderland area, including some that one of our farm members purchased on behalf of the farm. Some of these fields are 5 or 6 miles away from the Montague farm base, but good farmland is in very tight supply and high demand, so we have resigned ourselves to the fact that having a contiguous farm is not possible. We now have around 100 acres of potentially cropable land in the Montague area, and planted about 70 acres to vegetables & berries in 2013

Land Summery in 2013 - ~100 acres planted to crops (40 Granby, 60 Montague). Another 50 or more acres in summer cover crops (including acreage swapped with the chicken operation in Granby.)

**Vehicles:**
We have 5 box trucks (14 or 16' boxes) and once van for produce delivery. Almost all delivery trucks are in use daily from Tuesday until Friday each week, with some weekend use also. Two of the trucks are insulated and refrigerated. For in field harvesting and other jobs we use mostly old pick up trucks. We have a fleet of about 7 field trucks for Montague and 3 in Granby. Due to breakdowns on these vehicles we have lost much crew time and had some major frustrations & would like to upgrade the vehicles. We pay our mechanic about $100,000 per year (parts and labor) to repair and maintain the farm vehicles and farm machinery.

**Management Structure:**
As the farm has grown in scale, we have developed a management team structure. These 10 positions we consider the Core Management Team, although there are multiple additional leadership positions within the farm.

**Ryan Voiland** – co-owner. Overall production manager (crop plans, weekly production to do lists, weekly harvest notes and CSA contents plan, & all direct seeding at both locations), General Manager Functions (finances & budgets, banking, land deals, capital equipment purchases, and everything else that comes up.) Also does some farm stand delivery and farmers market display work each week.
**Sarah Voiland** – co-owner. Marketing & Communications Manager. Oversees the HR Manager and the labor budget for the farm. Types of tasks include constant contact e-mail communications with the farm members; web & brochure marketing, hiring and oversight of other farm managers, and helping Ryan make major decisions about the farm.
**HR Manager**- This person hires, fires, manages work schedules and is responsible to keep an adequate work force lined up for all the farm needs. The farm employs up to 90 people at peak season, so doing all of the paperwork and coordination is a substantial job.
**Logistics & Wholesale Manger** – This is primarily an office job. This person coordinates all wholesale orders and all of the trucking & logistics involved in getting the produce to the CSA locations and to other customers. This person also does purchasing of produce that we buy in from other farms (fruit shares, eggs, etc).

**Montague Production Manager**- Responsible for executing the weekly production plans. This person does much tractor work himself, but also manages the other tractor operators, field & weeding crews, irrigation, and anything else involved with growing the crops in Montague.
**Granby Production Manager-** Same as Montague except for Granby location.
**Bedding Plant Manager**- Manages the plant growing process in the Greenhouses in the winter and spring and coordination of wholesale plant orders. This is a seasonal management position.
**Montague Planting Manger-** Oversees greenhouse seeding for field plants, and also the transplanting process in Montague.
**Montague Harvest & Packing Manager**- Builds the daily harvest lists for both farm locations based on orders and CSA distribution plans. Is in charge of all aspects of the harvest and packing process at the Montague location, and the many employees who are part of this process.
**Granby Harvest & Packing Manager** – Same as Montague, except fewer overall people to manage, since less to harvest at this location.

**Office Systems & Software:**
Member Management – We have hired a software expert to customize a file maker data base for keeping track of our CSA members, their share options, their payments & past members / mailing list. We have a part time person who manages the input of this data. This CSA coordinator position also handles the general farms e-mail inbox by answering questions and changes from members, or forwarding e-mails to the correct person within the farm.

Online Sign Up Forms – Increasingly more and more of our members want to sign up, make payments or renew their CSA shares online. We accommodate this by using formstack sign up forms that are linked to our website. We take online payments via pay pal (which allows people to charge it to any credit card they want to use.) The system is organized to automatically send the customers an e-mail as soon as we receive an online payment.

Financial Recordkeeping – We keep all of the farm financial records on quick books. We have a bookkeeper who works 1 day a week to enter all receipts, cut checks to pay our bills, balance bank accounts, and work with Ryan and the farms hired accountant for tax preparation season.

Payroll – We hire Farm Credit East to do the payroll every other week and all associated filings. We had two other payroll firms before Farm Credit over the years, and consistently had problems. The value of a payroll service that understands and specializes in farms is essential.

Pick and Pack – Consistently accurate order fulfillment remains one of our biggest challenges. We currently use an excel spreadsheet that is updated by the Montague Harvest Manager for each harvest day (we pick Monday, Tuesday, Wed & Thursday each week). This person compiles all orders (the CSA share plan, bulk orders from members, wholesale orders and orders from our farm stand managers) into a single comprehensive spreadsheet organized by crop, picking location, picking crew & harvest vehicle. This list includes a breakdown of individual orders for the packing shed to use, and also totals for each item for harvest crew leaders to use when picking in the fields. We feel that with improved software we could make a better, faster and more foolproof system for managing the daily harvest. This is something we are slowly pursuing.

Production Plans- These are all done using many different excel spreadsheets that have been customized over the years. For many years Siga Field software was used for input and rotation recordkeeping, but this program was recently discontinued in favor of a carefully crafted spreadsheet.

**Production Systems:**
Our production practices and tools are reasonably standard for organic vegetable operations in New England. Implements we use include Imants Spading Machine, Chisel Plows, Perfecta Harrow, Disk Harrow, Williams Tine Weeder, Kenco Bed Former, Planet Jr Seeder, Water Wheel Transplantors, Penns Creek Boom Sprayer, Undercutter Bar, Two Bed Potato Diggers, and others. For Tractors we have 4 larger (60 HP or more) and two cultivating (G & an offset ford) in Montague and 2 larger units and three cultivating units (two G's and offset case) in Granby. The larger tractors include several Massy 573's, which we bought new, but all of our more recent acquisitions are John Deer's as the Deer dealers and parts service seem to be somewhat more reliable. We insist on tires that are less than 14" wide and creeper gears on all of the larger tractors in order that we can do specialized vegetable farm work like spading and transplanting. Each location has a complete set of equipment for what needs to be done.

We currently use a harvest isle system with 10 ft sod breaks planted after every 8 beds of growing space. This system has some significant advantages (easy to keep track of crop locations and rotations over time, easier access when fields are wet, good place to spray from, beneficial insect habitat within the fields, less wind erosion from fields open all at once). Drawbacks include the lost space for crop planting (2/10's of the crop land), encroachments of the grass sod sometimes interfering with the outer beds of a block, need to establish, mow and maintain the harvest isles. Despite internal debate among the farm staff, we continue with the harvest isle system for now thinking there are slightly more advantages than disadvantages, but continue to contemplate changes to this system.

Many other details of production systems could be discussed, but will be left for other presentations and discussions.

**Finances:**
We have found the financial viability of farming at this scale to continue to be almost as elusive as when we were a smaller scale operation. Despite sales of around 2 million per year, our net profit before capital expenses remains well below $300,000 per year. We typically invest about $100,000 - $200,000 per year in capital expenses (equipment and buildings), and then have to pay our mortgages (~ $80,000 per year). This leaves very minimal take home profit for the owners. For the farm itself we also do not feel we are keeping up with maintenance on many of the existing buildings (painting, new roofs, etc.) and we have many projects that we feel should get done (solar panels on more of our south roofs, improvements to buildings and facilities, better vehicles and equipment.) To often in the last few years we are feeling forced to put off these types of improvements and try instead to get by with what we already have. Overall we are trying to find solutions to our systems and farm arrangements that will improve our margin by $200,000 or $300,000 more per year, all while also increasing the wages of our staff by 15-25% over the current rates.

Our we meeting our goals as farmers?

We feel that by increasing in scale over the last few years we have moved the business in a direction that is closer to the goals of being able to successfully serve the needs of the farm customers, made a significant positive impact on the availability of local and organic food in MA, improved our ability to do farm tasks on time in order to optimize environmental and horticultural goals, and allowed our family to live in a beautiful setting near the confluence of the sawmill and Connecticut rivers.  Nevertheless we still feel that our farm is at times overly demanding on our time and that of our managers, very stressful to manage, and not as financially rewarding for us and our employees as work that requires this level of skill, dedication and grit should reward.

## A Decade of Experience with a Multi-Farm CSA – Local Harvest CSA

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**My farming experience.** I have been a farmer for 33 years. We have been certified organic for 27 years and CSA farmers for the past 23 years. I have been part of three agricultural marketing cooperatives (first as a farm worker, then as a farmer for a wholesale growers' cooperative, and now as a farmer in Local Harvest CSA, a multi-farm CSA located in Concord, New Hampshire).

**Who we are:** We are six farmers who are all certified organic. Together we have over 150 years of farming experience and well over 100 years of being certified organic. Between us we farm over 100 acres. We are all located in central New Hampshire. Our farms are: Kearsarge Gore Farm, Stone Ridge Farm, Middle Branch Farm, Vegetable Ranch, Blue Ox Farm and Good Earth Farm. Our baker is Abigail's' Bakery, who bakes certified organic breads.

**Our CSA History.** Our start came in 2002, when together with NOFA-NH, we wrote a SARE grant and received a one-time startup grant the following spring. We spent all of 2003 meeting and writing documents to get set up for business. We legally incorporated under NH Statutes as an agricultural marketing cooperative. Under New Hampshire law we are a non-profit corporation, but we are not a tax-exempt non-profit for IRS purposes. We pay taxes on any "profit" that we make.

In 2004 we had 103 members. We have continued to grow gradually and now have about 350 members. We rent a church hall one day a week and do satellite CSAs to various locations a second day a week. We sell vegetables for 26 weeks a year, with a 3-week spring plan, an 18-week summer plan and a 5-week fall plan. We offer single and family shares, with a bread option. We have four employees: a produce manager at the site, an office manager, a marketer and a crop production manager.

**Our future.** We are trying to expand. The market for CSA members is getting tougher each year. The competition is strong. When we began our own individual farm CSA in 1991, there were fewer than 100 CSAs in the US. Now there are over 6,000 CSAs nationwide. Likewise, when our group of farmers started Local Harvest CSA in 2004, we were one of the only CSAs in the Concord region and there were only a few farmers' markets. Now there are multiple CSAs and farmers' markets in Concord and every surrounding town. Like every individual farm and agricultural cooperative, we will need to adapt in order to survive and thrive. We would like to have a permanent home someday.

**Benefits of a multi-farm CSA:**

For the consumer, there is less risk of missing crops entirely some years or having skips in production. It is difficult for one farm to grow all 40 different vegetables each year. Even if a single farm can get every crop once or five times each year, the consumer might have hoped to have them five or fifteen times over the course of the season. With multiple farms, there is greater crop variety and crop consistency throughout the season.

For the farmer, it allows farmers to diversify if that is their farm model, or to specialize if that is their farm model. Also, it creates a neighborhood of farmers to talk with, share ideas and compare notes. It also allows individual farms access to a broader number of local food enthusiasts who may be interested in another aspect of your farm (e.g. – cordwood, maple syrup, meat, bedding plants).

**Good advice we received before we started:** (from Brian Henehan from Cornell University, one of the country's leading experts on agricultural cooperatives, and Lynn Byczynski, editor of *Growing for Market* magazine and a farmer member of the Rolling Prairie Alliance, a multi-farm CSA in Kansas):

1. Keep the quality of your produce high.

2. Take enough money out as a commission so the coop can run. It is a business of its own and needs sufficient resources to do a good job.

3. Find and hire good people to run the business.

4. Before you actually sell any produce, take a year and get to know each other and write down everything – make rules for how to deal with situations. It will make things a lot easier in the long run.

**12 things to talk about and include in your rules:**

1. Legal organization. Each state has specific laws permitting the incorporation of agricultural marketing cooperatives. These state statues are all based upon the legal framework established by the federal government in the Co-operative Marketing Associations Act in 1922 and the Cooperative Marketing Act in 1926. The specific state statutes are a good model to follow when choosing your legal framework and writing articles of incorporation and by-laws. Write a Marketing Agreement that each farmer will sign each year. That will become the foundation of your day-to-day operations. It will help you establish guidelines and expectations for the relationship between the farmers (individually) and the cooperative (as a group). Include a framework for dispute resolution. Plan for predictable things that can go wrong and detail how you will deal with them. Remember that the farmers and the cooperative are distinct entities. Also, purchase general liability insurance and workers compensation insurance as a cooperative.

2. Leadership structure. By law, each farmer gets one vote. Who will be on board of directors? What does the board of directors do? How will daily decisions be made and by whom? What is the system for accountability and transparency?

3. Quality standards. Make an official chart of standards for every item you sell. What will you do if substandard items are delivered?

4. Create bidding and sales systems. How will you decide which farmers get to deliver which crops and in what quantity? Will you treat new markets and existing markets the same within these bidding and sales rules?

5. Compatible farmers are key. Big/Small farms. Diversified/Specialty farms. Existing/New farms. Are you open to all farm models or do you have a farm type that you want to work with? Will you be open to new farmers? What are the requirements to join (e.g. – certified organic, certificate of farm liability insurance)?

6. Pricing. How will you determine and set prices? Will you sell everything in units? Will items be pre-bagged or bunched, offered by the count or offered in loose bins – or some combination of systems?

7. Budget, Equity Funds and Patronage Dividends. Set aside enough money to have a capital fund. Read up and follow all the IRS rules regarding Patronage Dividends. What is the commission rate? What will you do if you have a surplus or a deficit in any given year?

8. Employee supervision. Who is in charge of supervising employees? Write job descriptions each year. Will you hire in-house workers, from CSA members, or the general public?

9. Crops offered and site issues. Will you focus on fruits and vegetables? What about eggs? Milk? Meat? Bread? If you (the cooperative) take possession of the crops for three hours between farmer drop-off and customer pick-up, then does this change your legal situation regarding products like meat and raw milk? What are relevant state and federal laws for those products – they oftentimes are different than if you sell them directly from the farm. Will you offer bulk purchases and extras at the site? Customers like extra benefits such as a swap table and a vacation policy. Will you offer "member choice" (e.g. a complete pre-order list) or build member choice into the site with selections among crops as customers walk down the tables? Also, be prepared for the Food Safety Modernization Act. Multi-farm CSAs may be required to adopt a number of measures, potentially including labels of which crops come from which farms each week in order to provide tracking. (*Note*: this paper is being submitted before the final FDA rules will be released on November 30$^{th}$).

10. Location. Where will you sell the goods? Some options include: a permanent location (your own building), a rented location (e.g. church hall), satellite CSAs (pickup truck in a parking lot), at business sites (employee CSAs), or at one of the farms?

11. Larger community. Make a relationship with a local food pantry or soup kitchen to handle the unclaimed produce. Get involved in some local community events.

12. Internal competition. What rules will you make regarding individual farmers competing with the cooperative CSA and vice versa? This can be a pretty contentious issue, so try to talk about this ahead of time so that when real world examples come up, you have some philosophical principles in place.

A multi-farm CSA can be a great benefit to each individual farm. It takes a lot of work and dialog, but is well worth it. A couple of our farmers (Jill Perry and Scott Franzblau) wrote a 130 page handbook on multi-farm CSAs. It is called Local Harvest and is available for free online from SARE at: http://agmarketing.extension.psu.edu/ComFarmMkt/PDFs/local_harvest_csa.pdf

**Description of an IPM Program for Peaches**

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Developing an Integrated Pest Management (IPM) program for peaches involves more than putting together a pest spray program. It involves a pro-active approach to growing, beginning with site and cultivar selection, and an understanding of cultural practices that will help to delay, reduce or eliminate potential problems. It also involves an understanding of the life cycle of the pest, (whether it be insect, mite, disease pathogen, weed, nematode, etc); knowing which insect vectors which disease pathogen; being able to identify beneficial and understanding their life cycles; understand how the environment impacts potential pest problems and plant health; an understanding of how different pesticides work and the proper timing; understanding and utilizing alternative management methods; and understanding economic and injury thresholds.

Cultural practices:

1. Avoid varieties susceptible to bacterial spot. When sighting a new peach block, keep it away from an existing block of susceptible varieties.
2. Maintain healthy trees
    a. Prune correctly. Opening up the tree allows for rapid drying, reduces disease incidence and allows for optimum spray penetration. Remove small weak shoots in the center of trees to reduce Perennial canker incidence.
    b. Prune at the proper time. Peaches are best pruned once growth has started in the spring to reduce cold injury. Open wounds are entry sites for perennial canker organisms.
    c. Maintain healthy trees with appropriate nutrient levels in the soil and trees. Use routine soil and foliar analysis. Avoid late summer and fall nitrogen applications that will encourage trees to grow late into the fall.
    d. Avoid damaging trees with mowers and other equipment. These wounds are entry sites for borers and canker development.
    e. Thin fruit to avoid limb breakage. Open wounds are disease and insect entry sites.
3. Remove and destroy mummified fruit and cankers to reduce disease inoculum.
4. Thin fruit so no two fruit are touching. This reduces moisture buildup which is needed for disease development, and reduces the potential spread of brown rot from one fruit to another.
5. Thin fruit for maximum size development and to avoid limb breakage.
6. Control broadleaf weeds that harbor plant bugs and native stinkbugs

Understanding potential pest problems, life cycles, number of generations/year, overwintering sites:

1. Major disease problems
    a. Bacterial Spot, *Xanthomonas pruni*: infects leaf scars at leaf drop; infect in the spring around petal fall/shuck split and for ~ 3 weeks after.

   b. Brown Rot, *Monilinia fructicola*: greatest susceptibility is PF-3 weeks after and the 3 weeks prior to harvest. Control insects to reduce disease entry sites. Remove mummified fruit at pruning to reduce inoculum.
   c. Peach Scab, *Cladosporium carpophilum*: warm wet weather beginning at shuck split
   d. Perennial Canker: also called Cytospora canker, Valsa canker, Leucostoma canker: control by pruning
2. Major Insect problems
   a. Borers-PTB and LPTB: can be effectively controlled with mating disruption. Avoid bark splitting.
   b. Oriental Fruit Moth: adults out ~ PF; mating disruption is effective if 2-3 sprays are normally applied.
   c. Plum Curculio overwinter in hedgerows/woods. Problems generally highest in border rows. Stop migrating at 308DDs after Mac PF, base $50^0$.
   d. Catfacing insects - Plant bugs, stink bugs: majority of damage is done by shuck split
   e. Scale: overwinter on the trees; early season oil application against OW stage followed by insecticide against crawlers ~mid-June
3. Mites
   a. ERM overwinters on the tree; ~ 40 days to complete a generation at $55^0$F and 10 days at $75^0$F. Heat loving, summer problem.
4. Weeds: a plant growing where it is not wanted. Harbor insect pests (plant bugs, Stinkbugs)
   a. Annual, perennial, biennial, grass, broadleaf
   b. Some are easier to control with late summer-fall herbicide applications.
   c. Some are easier to control with spring herbicide applications.
   d. Management options: cultivation, herbicides, landscape fabric, mulch, flaming

<u>Biological Control</u>

1. Predators of mites:
   a. *Stethorus punctum*, a lady beetle, overwinters in weeds and leaf litter around the base of trees
   b. *Orius insidiosus*, Minute Pirate bug, overwinters in leaf litter in the orchard
2. Predators of Green Peach aphid*, Myzus persicae*
   a. lady beetles, lacewings, syrphid flies, soldier beetles and predaceous bugs

<u>Monitoring & Record Keeping</u>

1. Keep records of emergence time, location, numbers of insect & mite pests. Maintain environmental records combined with management tools utilized to better understand factors that increased or reduced insect and disease problems. Historical records are important to understanding what was done and what can be tweaked for better control in upcoming seasons.
2. Monitor and record trap captures. Understand how trap captures correlate to potential problems and when pesticides or other management tools are needed.
   a. OFM: >15 moths/trap 1st generation, >10 moths/trap later generations.
   b. PTB, LPTB: >10 moths/trap/week

3. Monitor trees, fruit
    a. Green peach aphid – 2 colonies/tree between PF and shuck split, 5 or more/tree after
4. Temperatures
    a. Plum Curculio adults become active when temperatures exceed $60^{0}$F
5. Using Degree days calculations:
    a. OFM second spray application suggested at 360 DDs after first trap catch
    b. Plum Curculio predicted to end migration into orchards at 308 DD after Mac PF, base $50^{0}$.

<u>Economic and Injury Thresholds</u>

Economic thresholds are used to determine the point at which if a management tool (usually a pesticide application) is not used, the dollar value of the crop loss exceeds the cost of the pesticide application. Economic thresholds have not been established for all insect pests. Injury thresholds are subjective and are determined by the individual grower. For example, one grower may have a zero tolerance for damage from plant bug while another may tolerate 4% damage.

1. Plant bug and Plum Curculio suggested injury level is 1-2% new damage
2. OFM has no economic threshold
3. Bacterial Spot treatment level has been suggested as 5% of fruit infected or 20 leaves show lesions.
4. Brown rot blossom blight suggested treatment level is more than 2 infected fruit/10 acres. However, if you have a history of Brown rot, have mummified fruit and/or cankers, and the weather conditions are conducive, preventative fungicide applications are recommended

<u>Alternative Management Options</u>

Mating disruption uses dispensers to emit the female pheromone while playing with the male psyche, tricking the males into believing they are following the scent of the female when they aren’t. Isomate PTB-Dual has been used successfully for the management of both PTB and LPTB while Isomate OFM-TT is for Oriental fruit moth control.

## Recent Trends in Peach Pruning

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Our ongoing research shows that training peach trees in V-shaped growing systems has potential to increase yields and improve fruit color in Mid-Atlantic peach orchards, but some challenges remain. One challenge is that these trees are tall and require ladders or platforms for workers to access the tree tops for hand thinning, harvesting, etc. Another is the difficulty in renewing one-year-old fruiting branches (laterals) in the lower canopy.

The natural growth habit of peach trees, coupled with peach tree growth response in relation to sunlight, and the growth response in relation to renewal pruning all play a role in how successfully the canopy is managed with pruning and training. The growth habit of peach trees is defined as acrotonic; that is, the most vigorous shoot growth is out at the periphery of the canopy.

In addition to the inherent tendency to be strongly acrotonic, the buds, leaves and young shoots of peach trees are intolerant of shade. Any portion of the canopy which is in shade becomes unfruitful and dies within just one or two seasons.

Furthermore, renewal pruning is relatively unsuccessful in comparison to apples, because the secondary buds at the base of peach shoots tend to be weak and unlikely to grow into new shoots when a renewal cut is made. Regardless of training system or pruning practices, the productive zone of the peach tree canopy migrates up and out as a result of these three factors.

Canopy Height Management and Scaffold Heading:

The best long-term solution to restricting fruit tree height is to plant the trees on size-controlling rootstocks. Size-controlling rootstocks for peach are under investigation, and may offer a future solution to growers' desire for a shorter tree canopy. We probably don't want the Malling 9 of peach trees. Since the best peaches are produced on moderately vigorous one-year laterals, a moderate level of vigor is desirable for assuring adequate fruit size and quality. A semi-dwarf peach rootstock could strike a balance between adequate vigor for lateral renewal, while containing maximum tree height without excess re-growth. To-date, the closest thing to a semi-dwarf rootstock that is well adapted for the Mid-Atlantic region is Bailey.

Bailey produces a productive tree with good survival, but the size of trees on Bailey is about 90% of seedling; closer to “semi-vigorous” than “semi-dwarf” (Schupp et al., 2012). A new peach trial is planned for PSU FREC in 2014 that will investigate the role of size-controlling rootstocks in high density peach production systems. The potential roles of training, pruning and hedging should also be investigated, as growers are shortening peach tree height, and are being advised to head fruiting laterals (van den Ende, 2013), or to hedge fruiting canopies, without the benefit of research into the outcomes from these practices.

Training peaches to create multiple scaffolds per tree does little to reduce tree stature. Our 2007 peach systems trial showed that increasing the number of scaffolds on a V canopy tree from 2 to 4 or 6 did not reduce canopy height after 5 years. Loring tree height was not shortened by pruning in this trial until after the fifth growing season. By that time tree height had reached 13.9 feet (hex- and quad-V) to 14.4 feet (perpendicular V).

Some peach growers have experimented with low- headed V systems; adopting the narrow V canopy shape, while still attempting to maintain a pedestrian canopy. The heading cut used to shorten the canopy often creates problems. This cut is made into the upper half of a vertically-angled scaffold in a strongly acrotonic tree on a vigorous rootstock. As with all heading cuts into vigorous, young limbs with an upright branch angle and favorable light environment, the severing of apical dominance stimulates the regrowth of several new vigorous upright branches. If allowed to remain, these new branches worsen shading. The result is a shorter tree with worse light distribution in the bottom of the tree than if it hadn’t been pruned.

Another possible management strategy is to maintain the narrow canopy shape and shorter stature with a combination of dormant thinning cuts and summer pruning or summer shearing. Following scaffold heading, the expected vigorous regrowth may be prevented from shading by the use of summer pruning. Some growers are experimenting with hedging to reduce this regrowth. In both cases, selective thinning cuts will be required during the dormant season to remove undesirable secondary wood, and maintain the simple canopy structure.

Heading of Fruiting Laterals:

The acrotonic growth habit of peach is due in part to the strong influence of light on shoot growth, and in part because the secondary buds at the base of peach shoots tend to be weak and unlikely to grow into new shoots. While this problem is actually more acute in open vase trained trees, the loss of productive laterals in the lower section of V systems is very noticeable, since overall canopy height is not being managed with bench cuts. The bench cuts used to maintain short-statured trees are often severe, sometimes leading to loss of productivity and increasing the incidence of fungal canker infections, but such heavy cuts do stimulate the renewal of lateral shoots closer to the ground. While bench cutting slows the ascent of the canopy, it does not prevent it, and the severe bench cut pruning creates vigorous regrowth that shades the lower regions of the canopy and reduces peach orchard productivity and fruit quality. Summer pruning becomes mandatory to maintain flowering and fruit color in vigorous open vase trees. Peach growers have lived with this problem so long that it is generally regarded as “just the way it is”. In the Mid-Atlantic, 350 bushels per acre is considered acceptable peach orchard yield, when in fact 600 bushels of high quality peaches per acre can and should be attained.

Heading the fruiting laterals during dormant pruning may present a way of stimulating shoot growth closer in to the scaffold, while simultaneously reducing thinning costs (van den Ende, 2013). The new shoots stimulated by these heading cuts can then be selectively pruned to select new laterals for the following season. One concern with heading fruiting laterals is that it removes a portion of the best flower buds, leaving less-desirable basal buds to produce more of the crop. These buds often have lower potential to set and to produce large fruits. Studies to evaluate the effects of scaffold heading height, dormant heading of lateral fruiting shoots, and summer shearing on perpendicular V peach tree productivity, light distribution, and lateral shoot renewal are underway.

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**A 40-year Perspective of Research on Tree Fruit Diseases**

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Both tree fruit production and the supporting research/extension system in the United States have changed dramatically over the past 40 years. I began my career as a scientist in June of 1972 when I moved from Pennsylvania to Michigan to become a graduate student and research assistant with Dr. Alan Jones. My Ph.D. research explored the epidemiology of X-disease of peach. After completing my graduate studies, I moved to Cornell's Hudson Valley Lab in 1977. Thus, I have spent over 40 years immersed in applied research and extension for tree fruit crops in eastern United States.

One of the bemusing aspects of tree fruit research over the past 40 years is the way that broad themes emerged, were modified, and then were gradually integrated into our thinking and commercial practices. I have listed some of these themes, along with my tongue-in-cheek (and admittedly biased) short characterizations of them, in Table 1.

During much of the 1950's and 1960's, there was a pervading confidence that we could resolve all agricultural pest problems with pesticides. That perspective was gradually tempered by the realities of DDT pollution, development of resistance to pesticides, and public concerns about the safety of pesticides. Epidemiology, while providing invaluable insights concerning the biology of many diseases, in most cases failed to live up to the premise that we might pinpoint weaknesses in disease cycles that would enable farmers to control diseases with single well-timed interventions. Computer simulations helped us identify knowledge gaps and better organize our thinking, but decision support systems were and are limited by the knowledge of the program compilers and (for predictive systems) by the accuracy of weather forecasts. Crop modification by seed selection is as old farming. Both conventional breeding programs and genetic engineering of crops are promoted as faster/easier approaches to that age-old process of crop improvement. For tree fruits, "faster" is a relative term: In the early 1990's, scientists proposed that genetically modified disease-resistant apples would be commercially available in 10 years, but many factors, including intellectual property rights and public opposition to GMOs, have contributed to an extended delay or perhaps a permanent suspension for GMO technology that might benefit tree fruit production in eastern United States.

Table 1: Agricultural research themes that emerged or predominated at various times over the past 40 years, along with my perspectives on how proponents for each theme expected to change agriculture.

| | |
|---|---|
| Chemical controls (forever) | conquering nature |
| Epidemiology (saves the day) | timing nature |
| Computer simulations & decision systems | mimicking/predicting nature |
| Breeding for resistance & genetic engineering | tinkering with nature |
| Biocontrols | over-dosing nature with nature |
| Systemic acquired resistance | arousing nature |
| Organic farming | nurturing nature |
| Integrated pest management (IPM) | nudging nature |

Biocontrol systems have always had strong proponents, but I am not aware of any widely adopted biocontrols for diseases of tree fruits. Significant effort has been expended to develop biocontrols for storage diseases of apples, but getting biocontrols to work even under those controlled conditions has been very difficult. Getting plants to defend themselves by triggering "acquired resistance" sounded promising until scientists realized that plants keep those system inactive most of the time for a good reason: Turning on the resistance mechanisms associated with systemic acquired resistance requires energy and sometimes (often?) results in yield reductions. Organic farming, although wildly popular with media and the general public, has been successfully applied on very little of the fruit acreage in eastern United States because of the wide range of pests that attack, damage, and sometimes kill fruit trees in our wet humid climate.

Integrated pest management has been an over-arching theme throughout most of my 40-year career, and IPM concepts have become so integrated into our thinking that it is virtually impossible today to differentiate IPM farmers from "non-IPM" farmers. In fact, like many of our publicly funded ag research and extension programs in the U.S., IPM programs are suffering because they have been too successful. In some circles, folks view the IPM mission as having been completed and therefore no longer worthy of continued funding.

Looking forward, the biggest challenge will be convincing the non-farming 98% of our population that continued investment in agricultural research is essential for the long-term health of our society. Only recently have I realized that many folks (sometimes including funding agencies and college administrators) assume that after a 40-year career I must have permanently solved fruit disease problems and educated fruit farmers to the point that no further effort should be required. Those outside of agriculture cannot fully grasp how each season is different; how imported pests, new cultivars, and availability of new pesticides combine to make last year's practices obsolete; and how competition from other regions of the U.S. and the world requires a constant investment in research and extension to keep fruit farms economically viable.

From my perspective, it appears almost certain that private crop consultants will increasingly assume the roles formerly occupied by extension educators because funding for extension will continue to decline at both the federal and state/county levels. Yes, electronic technology will allow the remaining extension geeks to continue providing information to huge audiences via websites and web-based conferences, but those electronic platforms will most likely remain incapable of tailoring information to the unique situations found on individual farms in the way that extension educators did in the past or in the way that crop consultants are doing it today.

What is less apparent, however, is how private enterprise will generate the kind of applied research that, over the past 100 years, has emanated from tax-funded land-grant universities and made U.S agriculture so productive and successful. Throughout the United States, the traditional applied-research infrastructure of the land-grant universities is being dismantled. Field research stations that were formerly operated by universities are either being closed or they remain open only because the agricultural producers in the region are providing direct funding to cover at least part of their operating costs. Professors on university campuses are either overtly or indirectly discouraged from developing field research that tackles the tough problems faced by agricultural producers. If present trends hold, land grant universities will continue ag-related research that will enhance our basic understanding of biological processes in plants (e.g., via studies with model systems like *Arabidopsis*), but there will be an increasing gap in "translational research" that is needed to incorporate new knowledge into actual farming practices.

I can foresee several approaches for funding applied agricultural research over the next several decades, but most of them seem either improbable or fraught with the probability of unintended consequences:

1. Public opinion and politics might eventually change enough to reverse current trends and generate improved funding for applied ag research and extension. This scenario is likely only if the U.S. encounters a major food shortage within the next 5-10 years, before the land-grant infrastructure is fully dismantled. Even then, the increasingly top-down management style imposed on university ag research (from Congress to USDA to grant review panels to university administrators) has generated an inefficiency and risk-aversion that would almost certainly impede a return to the productive applied research programs of the last century.
2. As noted earlier, there are an increasing number of cases where university field stations operate via shared funding from universities and from agricultural producers. The advantages and pitfalls of this approach are not yet fully apparent. However, the problems noted with top-down management and risk-aversion in universities will impede these models while farmers' common tendencies to focus on short-term problems and "safe" research investments may further limit a scientist's freedom to operate at such jointly funded field stations.
3. Large commodity groups and/or large corporate farms will develop their own in-house R&D programs to conduct translational research. Such endeavors will almost certainly generate proprietary information that will not be available to competitors of any size.
4. Private foundations and philanthropies could provide funding for applied ag research programs, but most foundations and philanthropies balk at supporting infrastructure that they do not directly control. As a result, philanthropic funding in U.S. agriculture has been mostly limited to specific projects of interest to the philanthropists, an approach that does nothing to address the funding required to maintain the infrastructure that is essential before scientists can seek grant money for specific projects.
5. Large agribusinesses have always had huge in-house research programs that generated the products (seed, pesticides, fertilizers, etc.) that have been essential for advances in agricultural production. Because this is an established and functioning model, I suspect that not only will agribusinesses continue as important sources of innovation and applied information in the future, but also that they will increasingly fill the void that is being created by the current down-sizing in land-grant universities. Both farmers and the general public may cringe when confronted with the possibility that land-grant universities are ceding their research/extension roles to agribusiness conglomerates. However, I can't foresee any events that will derail this transition despite the fact that the public increasingly associates "Monsanto" with everything that they dislike in our food production system. The fact that many of agricultural suppliers have merged and re-merged to the point of gaining almost monopolistic power in the marketplace is a concern that should receive more publicity.
6. Individual innovators on small farms will continue to conduct their own informal research, and many of these innovations, even if they are not validated in controlled trials, will be shared and adopted by other farmers. Maintaining strong commodity or regional farm associations will be essential for maintaining social interactions needed to stimulate ideas and share results generated by farm entrepreneurs.

My friends call me a pessimist, but I argue that a pessimist is nothing more than an optimist with experience. My experiences over the past four decades lead me to suspect that, as with the ag research themes outlined in Table 1, we will gradually abstract the best from all of the applied research sources outlined above, plus many others that I failed to visualize. No matter how events unfold, we can be confident that farming will survive because, without it, no one survives!

**Evaluations of New Peach Tree Training Systems**

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## Introduction and Objectives

We compared and demonstrated upright and conventional growth habit peach varieties within four training systems, ranging from high to low planting density in growing years 2007 to 2012 and analyzed yield results, tree morphology, labor, and economic value for tree systems. This is an ongoing long-term project, and this report summarizes results for 2012, as well as some cumulative results since the beginning of the study.

## Plan of Work

A peach orchard was established at the Penn State Fruit Research and Extension Center (FREC) in Arendtsville, PA to compare the performance of Sweet'N'Up, a peach cultivar with an upright tree growth habit, and Loring, a standard growth habit cultivar chosen because it has a similar time of ripening as Sweet-N-Up. Each variety (growth habit) is being grown in three high-density systems and one standard density peach system. The systems include perpendicular V at 5 ft in-row spacing (PV5), quad V at 7 ft in-row spacing (QV7), hex V at 10 ft in-row spacing (HV10), and open center at 14 ft in-row spacing (OC14). All four systems are planted at 18 ft between rows. The varieties and systems are compared on the basis of cumulative yield, fruit size, color and quality, tree size, establishment costs, production costs, and return on investment. These data are being used to make recommendations to growers as to which systems offer the best production of marketable yield. Additionally, the systems are evaluated for suitability for mechanization, and evaluated for use with mechanical labor-saving aides, such as the Darwin mechanical blossom thinner and labor assist platforms. Production practices such as pruning, hand thinning, and harvest are also evaluated in the different growing systems to determine which growth habits, canopy parameters, and spacing provide optimal productivity and labor efficiency.

In 2012 we conducted an analysis of red fruit coloration of fruit samples from the third harvest date of each cultivar. Samples of twenty-four fruits per plot were collected from the lower canopy in all seven plots of each training system and the extent of red blush coverage of the fruit surface was measured by digital image analysis.

## Results and Discussion

Cumulative tree growth was assessed by measuring trunk cross-sectional area annually for all years of the study (Figure 1). In each year, trunk growth increased proportionately with increasing tree spacing. The open center trees had the greatest trunk growth, followed in descending order by the HV10, QV7, and PV5 systems. The closer the tree spacing, the less the trees grew. This was true even in the first year of planting, when tree-training practices were essentially the same for all systems. We surmise there was competition between trees at close spacing, even when the trees were newly transplanted and took up the smallest portion of the space allotted them.

In 2009, Sweet-N-Up produced more yield than Loring, but Loring produced the most annual yields from 2010 to 2012, and consequently has produced higher cumulative yield (Figure 2). All of the V systems, planted at higher tree density, produced more fruit per acre than the OC14 trees. QV7 trees produced the greatest cumulative yield for with both varieties, while HV10 yields were greater than PV5 yields.

Annual yield for the HV10 and QV7 systems was very similar and greater than that of the other systems in 2012. In 2012, Loring QV7 yield (641 bushels per acre), and HV10 yield (628 bushels per acre) were greater than that of the traditional OC14 (295 bushels per acre) by a huge margin. Similarly, cumulative yields for HV10 and QV7 (1641 and 1730 bushels per acre, respectively) far out-distanced the OC14 (939 bushels per acre cumulative yield). While the PV5 also produced more cumulative bushels per acre (1515) than OC14, it produced less total yield and less large fruit than the medium density QV7 and HV10 trees. Thus we conclude that the additional investment in tree number at planting required to establish the PV5 system isn't justified. The QV7 and HV10 systems establish more bearing surface per acre, which explains the greater productivity of these medium density systems over lower- and higher- density systems (data not presented). Similar margins between systems were recorded for Sweet-N-Up, although yields were slightly lower than Loring.

Growers often observe that V systems produce more small peaches than those grown on open center trees. While all three V systems in our study produced more small sized fruit than the OC14 trees, the QV7 and HV10 also produced more 2.75 inch and 3.0 inch fruit than the OC14. All four systems received appropriate pruning to reduce excess crop potential, mechanical blossom thinning, and timely green fruit hand thinning. These cultural practices, followed by trickle irrigation during final fruit swell, resulted in highly desirable fruit size distribution, regardless of training system. Our results to date suggest that this is the result of higher productivity, and should not be considered a failing of closely planted V systems to produce a quantity of large fruit, if good management practices are used.

Figure 3 shows representative images after preparation for digital color analysis. The black sections of each fruit image show where the skin is red, while white sections lack marketable red pigmentation. Loring fruits from the lower half of the canopy of all 3 V systems were redder than those from the open center trees (Figure 4). There were no differences in the extent of red coloration between systems for Sweet-N-Up, which characteristically colors better than Loring.

The upright growth habit of Sweet-N-Up offered few advantages over the standard growth habit in this study. Sweet-N-Up was more precocious in year three, and produced somewhat redder fruits than Loring.

With the development of mechanical blossom thinning and mechanized labor platforms, the loss of labor efficiency associated with the need to use ladders in tall tree systems can be greatly reduced. Open center training to produce a pedestrian orchard has reigned as the predominant system in the eastern U.S. for over 150 years. The results of this study show unequivocally that a change in our peach orchard training systems is long overdue. QV7 is a productive and easy to train tree wall system that facilitates mechanization for labor efficiency.

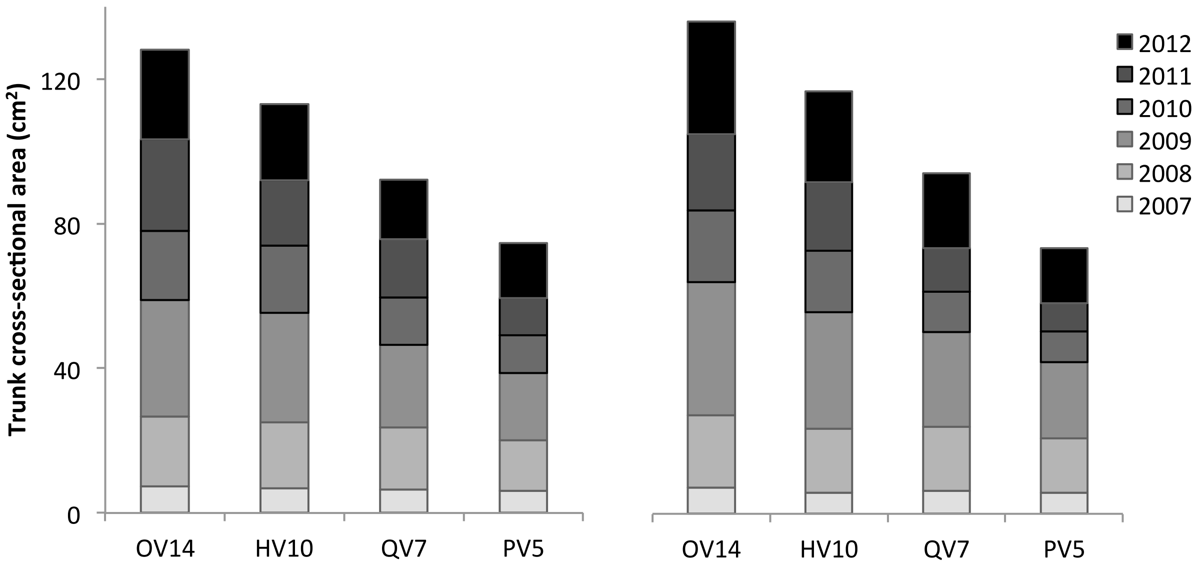


Figure 1. Tree size as indicated by cumulative trunk growth per system in all years of the trial (Sweet-N-Up left, Loring right).

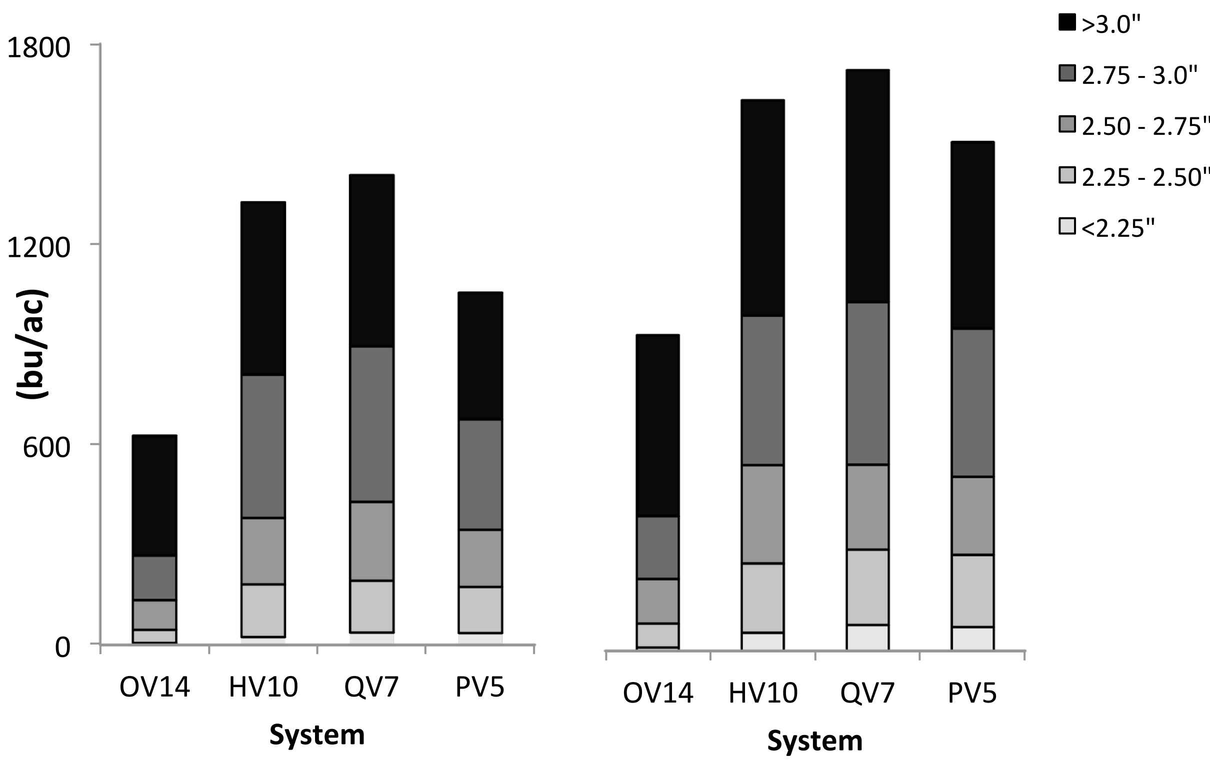


Figure 2. Effect of training systems and in-row tree spacing on cumulative yield (bushels per acre) and fruit size (inches) of Sweet-N-Up (left) and Loring (right) peaches, 2009 - 2012.

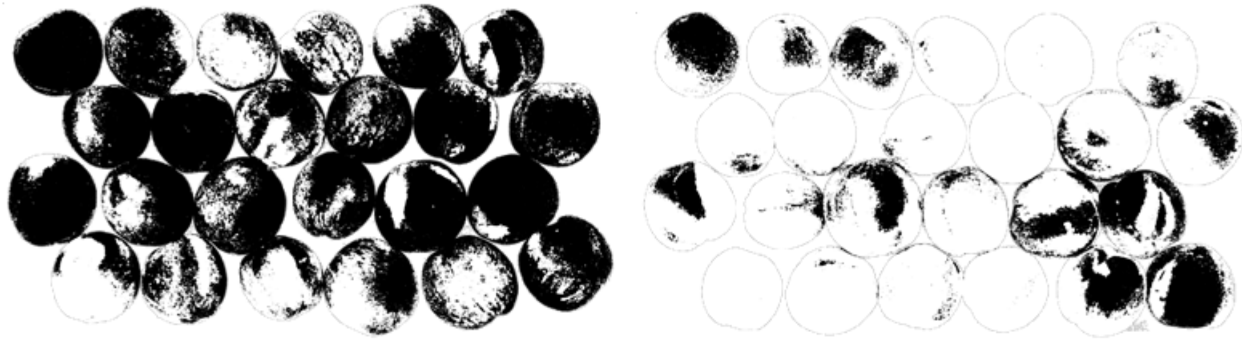

Figure 3. Digital images classified into blush (black) and non-blush (white) regions of Loring peach fruit sampled from the lower canopy of two training systems, 2012 (HV10 system, left; OV14, right).

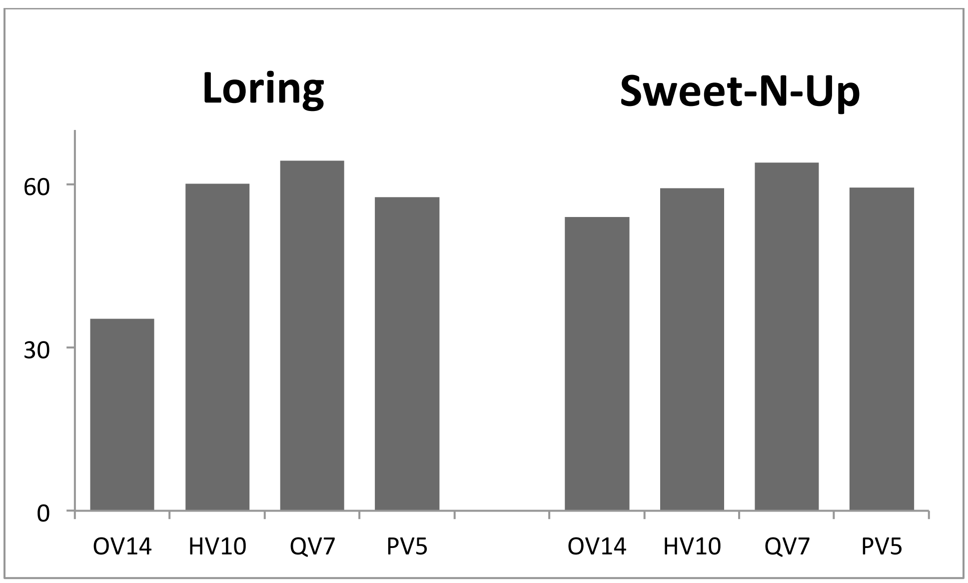


Figure 4. Extent of red blush coverage on the surface of Loring and Sweet-N-Up peach fruit sampled from the lower canopy of four training systems, 2012.

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## Simple Rules: Mechanization for Higher Labor Efficiency

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In the Northeast, a fruit business can grow as big or as profitable as anyone can imagine. This is a place in the world where almost perfect environmental conditions produce high quality fruit for a large population market so close by. The career path of being an apple grower (whether you are a next generation fruit grower, a new comer, or a talented and already well recognized fruit grower) is one of the greatest professions of hard outdoor work. It requires having the right horticultural skills to succeed in the fruit business, but in addition you have to choose, implement, and execute good business strategies and you have to attract and hire the right group of people.

In the last few years I have tried to urge you to focus on orchard efficiency. I have also mentioned how critical the employees you hire are for the success of your business. I describe this by explaining you what I have called the 'Pyramid for Efficiency and Profitability" which is supported by you and the people in your team.

Because my unusual background has allowed me to see, compare, and connect things in a different way, please let me give you some examples by comparing typical South American fruit operations from Chile, Argentina, or Brazil and typical Northeastern fruit operations from New York, Michigan, or Pennsylvania. In the first case, the South American fruit operations are generally larger and corporate in nature, while here most of the operations are smaller and family run business. A Brazilian, Argentinian, or Chilean owner is less involved in the day-to- day operations, while here you are more or fully involved. In general, South American fruit operations have more technical support (technicians, agronomists) and more consultants involved such as University professors or private consultants, while here you have less technical support and fewer consultants involved. Hand labor is more available and cheaper in South America, while here labor is less available and more expensive. For example an average Chilean or Brazilian orchard worker can pick 3 bins per day, while here your pickers whether from Jamaica or Mexico can pick 5-6 bins per day. Therefore, a typical South American fruit grower is currently "less ready" to improve orchard efficiency and also his or her employees! So what about you? Are you ready to improve your efficiency?

Progressive US apple growers have been changing from big apple trees on seedling rootstock planted at large distances to more intensive planting systems (mainly on M.9) motivated by the economic need to modernize their fruit growing operation. They look for earlier yields after renewing the orchards, for better fruit quality, and for lower production costs compared to the traditional systems. Many of them are now in a position to take advantage of labor saving ideas and improve labor efficiency because they have the proper high-density orchard while other growers who have not been modernizing their orchards can't improve efficiency very much.

*What makes an orchard exceptionally good for improving efficiency?* It is one, which allows for implementation of partial mechanization for production of high quality fruit (a kind of assembly-line future for fruit production). The more complicated you make the tree in terms of making decisions, the harder the system becomes for you and your workers. With a very simple training system, workers have to make few decisions. A very simple training system also makes the fruitlets, branches, and fruit very accessible to workers for hand thinning, pruning, or harvest. Pruning is perhaps the best example I can use to explain this "simplicity" factor. Simple pruning rules make it easier for workers to be efficient in the orchard. Complex tree architectures create many possible courses of action for pruning, which can confound workers. When workers are faced with a superabundance of pruning cut alternatives, workers are afraid of making the wrong choice. As a result workers delay the pruning cut decision, default to the safest "obvious" cut, or avoid choosing altogether. Your pruning crew ended up being less efficient. They work harder not smarter.

Today our economy and the uncertainty of a skilled and reliable labor source force you to balance two conflicting but equally important demands for success at a critical moment in this country: (1) **efficiency**, which comes from exploiting standard opportunities and (2) **flexibility**, which allows a US fruit grower to seize unexpected opportunities. It is a challenge because being a NY fruit grower demands a lot of your own personal and family time. Moreover, it is something you do outdoors expecting to make a profit in one of the few US industries "without a roof". Simply, it is a huge challenge and a very risky thing if you commit horticultural or business management mistakes. So ask yourself some tough questions. What is your goal as a fruit grower? Do you want to be among the best Northeastern fruit grower producer? Do you want to grow, pack, and sell your own fruit? Do you want to be fully vertically integrated? Do you want to produce fruit cheaper than others? Do you want to increase per-box returns by producing high quality fruit? Once you define your business strategy, avoid wasting time shuffling through piles of papers or tools, and keep your desk, truck, shop, and ultimately, your orchard well organized, prioritize a list of the tasks to carry out through the day, the next week, the next month, the coming season, the next year. Envision where you and your family want to be the next 5, 10 years. Prioritize the national and international educational conferences and tours you attend. Be smart and strategic when shopping for "variety clubs", "new technologies", or the "next big idea". Try working in a team, allotting tasks to co-workers, family members, and other helpers if possible. Have effective communication "change the focus from a top-down distribution of information" to a "bottom-up exchange of ideas" with your key employees. Plan cautiously to make sure a job is done properly the first time around.

Hopefully I have infused you with the mindset that allows improved efficiency and greater profitability. As with most things worth having, a culture of efficiency doesn't just happen. It takes work. But the payoffs are priceless.

***Note:*** Some apple growers consistently perform orchard tasks efficiently and on time while other seemingly similar apple growers struggle and are less efficient. The presentation will highlight practices of innovative NY fruit growers to work more efficiently in high-density orchards. Through the use of more than 20 mini-videos I will show how anyone equipped with the right orchard tools and/or platforms can work efficiently in a modern high-density apple orchard. The presentation will cover topics from apple tree nursery production to apple harvest to show how NY apple growers are working to reduce labor costs through the use of partial mechanization of orchard tasks.

**Profitable Production of Quality Winter Greens in Unheated NY High Tunnels**

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Pleasant Valley Farm is located in a valley in a rural town 25 miles northeast of Saratoga Springs, New York and we have been operating it as an organic fruit and vegetable farm since 1988. We have two children, Robert (age 21) and Kimberly (age 18) who were home-schooled, attend college, and are an integral part of running our family farm. We own 60 acres and rent our neighbor's 120-acre farm; we use a total of 5 acres for vegetable production, 1/2 acre for large fruits and 1/4 acre for small fruits, and keep another 3 acres in cover crops for rotation. We grow a diverse selection of more than 40 types of vegetables and fruits with organic methods (certified through Certified Naturally Grown www.naturallygrown.org) for retail sales at three area summer farmers' markets, two winter farmer's markets, and a small amount to several local restaurants.

Since 1992, we have been perfecting our season extension techniques and in 2006, we started a new venture utilizing high tunnels, with one completed in early 2007, another constructed in May 2008, and the third one in May 2012. They are permanent Rimol high tunnels (one 30'x144' and two 34'x144') with extended posts to allow us to have the sides open up extra high and enable tractors to get close to the edges along the inside. Ventilation is very critical in tunnel growing, and the automatic roll-up sides and very large end vents give us good cross-ventilation; HAF fans are important. Drain tile lines (4") were installed in stone on landscape fabric around the perimeters, which remove all the surplus water that is shed off the large structures and the drainage helps keep even moisture inside for the growing area. Two inch thick by 12" deep of rigid foam insulation was also placed on the outer edges to help with winter growing soil temperature fluctuations and inhibits water penetration. All tunnels are unheated except for an emergency back-up propane heater, and each has water from frost-free hydrants, as well as electricity, overhead and drip irrigation in each. We helped do much of the construction and chose to build them to last our lifetime, utilizing no wood. Everything is steel or aluminum except the coverings. All have polycarbonate knee walls and two have polycarbonate ends; 9-foot polycarbonate sliding doors were installed on all tunnels, which make access very easy in all seasons for equipment and workers.

We are learning how wonderful these high tunnels are for growing crops for year-round production. Our summer crops have included transplanted beans, basil, tomatoes, summer squash, and cucumbers, most grown with great success. Winter markets are growing and expanding all around our area, with seven within an hour's drive of our farm! For fall, winter, and spring production, we are growing spinach, lettuce, mesclun, Asian greens, arugula, kale, mustards, turnips, broccolini, and swiss chard. We have experimented with different hoop and row-cover structures during the winter, and even with very cold winters (5 to 16 below zero), all crops have survived (including Johnny's five-star lettuce mix) with 2 to 3 layers of covers and no supplemented heat. A new lettuce favorite is the Salanova varieties, which give great yields and are super winter hardy with no disease issues; for 2013-14 we are keeping data on successive weekly plantings, starting August 15th. We harvest weekly for the two Saturday markets that we attend, and the greens in the dead of winter increased our sales by about $750 each week in the 2008-2009 season and over $1200 per week in 2009-10. For 2010-11, sales from the tunnels averaged over $1350 per week.

Our harvest and sales records show the values of each crop in the tunnels (see spread sheet) and we tweak our planting dates each year, and now do several successive plantings to accommodate variations in fall weather. Our favorite salad mix varieties are: Sulu, Bolsachica, Blade, Refugio, Spock, Gaviota, and we are trialing many others as usual. All are seeded in separate rows for growth and disease monitoring; we try to only use DM resistant 1-25 varieties and use several organic fungicides if necessary (Double Nickel, Cease, and Regalia). Probiotics and Biologicals like Root Shield Plus, Actinovate, Serenade, and Mycorrhizae, are often used to promote healthy plants in all tunnels. Winter insects can usually be controlled with ladybugs, beneficial mites, and Aza-Direct. The health of the soils, nutrients, micronutrients, and monitoring yearly soil tests, as well as organic matter levels are key.

Each of the three tunnels are rotated yearly and they have 6-8 raised beds made by hand, some sections with Biotelo black plastic: One tunnel is planted to spinach and we have trialed over 50 varieties, with many being successful in different conditions. The second tunnel is salad mix, mustards, and arugula, with the salad mix always seeded in the middle raised beds. The third tunnel is transplanted with swiss chard and kale, with asian greens inter-planted among them. Onions (Forum and Bridger) have been grown successfully, as well as turnips, scallions, and other greens. The crops we continue to grow are the ones giving us the highest yields and we look at how long they are in the ground. Many are transplanted into the tunnels in October or early November, and we typically don't start harvesting until late November or early December after our field supply of greens is gone due to the weather. Transplanting allows the summer crops like tomatoes continue production late into the season. Our winter salad mix, which consists of 6-8 lettuce and 6-8 mustards/Asian greens is our most profitable winter green, grossing over $9 per square foot (or $400,000 per acre if extrapolated out—see spreadsheet). In 2011-12, all our winter crops combined averaged over $5 per square foot (and $227,000 per acre extrapolated).

In summary, through much trial and error since 2006, the winter greens production has proven to be a successful, profitable, and worthwhile venture, and our winter sales (6 months) are now equal to our summer sales at the markets. Customers are excited to come every week of the year and be able to get fresh, healthy greens. Our winter sales also include a wide variety of storage crops from our root cellar and other storage rooms. Each year, our system will be improved as winter growing becomes more and more popular, more research is done, and we become more experienced.

**PAUL & SANDY ARNOLD** **HIGH TUNNELS** **2011-2012**

**PLEASANT VALLEY FARM**

**SHOWING EXTRAPOLATED VALUE PER ACRE ON EACH CROP-We want minimum to be $30,000 on all crops grown**

**DATA FOR ONLY MID & LATE WINTER (Not Spring Lettuce, Broccolini, Broccoli Raab, etc.)**

| | | A | B | C | D | E | F | | |
|---|---|---|---|---|---|---|---|---|---|
| **ITEM** | **# Beds** | **Square Ft Grown** | **Acres (A/43,560)** | **Quantity Sold** | **Price** | **Total Value C X D** | **$/Acre E/B** | **Comments** | **Harvest Dates** |
| **ASIAN GRNS*** | **3** | 1,980 | 0.045 | 1372 | $3.00 | $4,116 | **$90,552** | .46#Bag/Bnch | 11/12 to 5/19 |
| **ARUGULA** | **1** | 660 | 0.015 | 1616 | $2.50 | $4,040 | **$266,640** | .15# Bag | 11/19 to 4/28 |
| **KALE** | **1** | 660 | 0.015 | 1097 | $3.00 | $3,291 | **$217,206** | .46# Bag/Bnch | 1/28 to 5/12 |
| **SALAD MIX** | **3** | 1,980 | 0.045 | 4621 | $4.00 | $18,484 | **$406,648** | .26# Bag | 1/1 to 6/1 |
| **SWISS CHARD** | **2** | 1,320 | 0.030 | 2480 | $3.00 | $7,440 | **$245,520** | .46# Bag/Bnch | 12/17 to 6/20 |
| **SPINACH** | **Whole tunnel** | 4,080 | 0.094 | 4286 | $3.00 | $12,858 | **$137,278** | .26# Bag | 11/25 to 4/3 |
| **TOTALS** | | 10,680 | 0.245 | | | **$50,229** | **$227,307** | **Average/Acre** | |

**Calculations to figure dollars per acre for each crop for the year using 43,560 squ feet per acre**

**All data from 2011-2012 Winter/Spring**

**Each 34' Rimol Tunnel has 7 beds that are approx. 660 square feet per bed (includes path)**

***Asian Greens are interplanted "French Intensive Style" between the kale & Swiss Chard**

***Asian Greens are from 2 plantings, one in the late fall, and one early spring**

**Arugula is from 3 successive fall plantings and one in late January**

**Kale and Swiss Chard are from one fall planting**

**Salad Mix is from 2 plantings, one direct seeded in fall, and one transplanted in about March 1st**

## Growing for Retail markets in S. New England with Field, Low Tunnel and High Tunnel Production

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Successful winter greens production requires a fundamental shift in the context from being a traditional summer grower. As an apprentice to winter growing, you will be learning to work with the dramatic changes in the suns' energy and the vicissitudes of temperature both above the ground and in the ground. We have all heard that the Eskimos have 32 words for the word 'snow'. Similarly, as a winter grower, you must no longer look at 'winter' as the grey cold period after thanksgiving to sometime in March when the crocus' show up. Like the Eskimo, you have to learn the language and dynamics that are involved with this season so you can take advantage of them; instead of them limiting your ability to produce delectable greens.

Many farmers' interest in Winter Greens developed from their observation that, at winter farmers markets, it is the farm stands that have the fresh greens that do a lands share of the business. It is now clear that one will sell a lot more onions and potatoes if your display is punctuated with vibrant greens of all kinds. What is needed is a plan for "seamless" production of greens from early October till the end of April. This will be achieved by starting your season outside in your regular fields; then about Dec 10th moving your production inside your greenhouses or high tunnels; and then finishing your season back out in the fields with plants you put in the ground back in late fall.

The most challenging phase of winter greens production is getting ready for and managing the "deep winter" or what has been labeled by many growers the "Persephone Period". It is the period from Dec 10th to February 28th; a period when, due to the lack of the suns energy, low temperatures and a high incidence of disease; most greens production in the greenhouse slows to a crawl. When Persephone is forced to return to Hades for her winter stint (see your Greek Mythology book), everything in nature seems to either die or go into a state of suspended animation. The way through this period is to use your greenhouses as a 'savings bank' from which you weekly withdraw your carefully grow greens, which you have been planting as succession since late September through the middle of October. If you have worked out the numbers and gotten your successions just right, by the time you are withdrawing your last greens, your first greens should be able to start cutting once more. And in two weeks time, by the Middle of March, you will be amazed at the rapid regrowth that is ushered in by the increase in the sun's energy and commensurate increase in air and soil temperatures.

The second most important point to prepare for your "seamless greens" production is to keep outside production going for as long as possible; (till December 10th) while at the same time planting and differentiating your seedings to make your 'early spring production' as flawless as your 'fall to deep winter production'. At Wishing Stone Farm, late spring greenhouse tomato production is a very important part of our crop profile. As a result, we must transition out of our greenhouse greens production in March and early April to make way for our spring tomato crop. This is why it is so important for us to have field produced greens so well organized that we are only using our greenhouses for winter greens from October to March. We achieve this biseasonal production by consciously working on the field production for the (March to May) period at the same time we are working on the (September to December) season production. In simple terms, we plant tight 'in row' plantings for the early winter greens and at the same time, we will plant more open seedings for late winter (March to May) production. For example: on October 5th we will plant a five row bed with "Blue Vates" (B. oleracea) at a rate of 24 seeds per foot and then (the same day) move to our (March to May) field and plant the same "Blue Vates" at a much thinner seeding of 12 seeds per foot. We repeat this process for a number of other greens. In the (March to May) harvest period we want larger more traditional size bunches, which necessitates giving the plants more space for soil, sun and nutrients. Versus, the (September to December) harvest we are more interested in weight and volume and therefore want to rapidly cut bunches that produce 20-28 stems with adolescent leaves at the top. Another production technique we start in mid fall for Spring harvest is Kale black plastic production. For this we use greenhouse grow plugs and plant them in October and let them mature. When the nighttime temperatures are starting to drop into the low twenties, we will cover these plastic rows with 1/2" electric conduit hoops bent with the Johnny's low tunnel hoop bender. We customized these to make them taller than wider feeling that the extra height helps with light and air quality, which assists with rapid growth in the spring. Our goal is for the black plastic production kale to have reached a good level of maturity, before we cover them up to go through the 'Persephone Period'. A plant with good root growth and substantial top leaf development will be able to better capitalize on the late winter sun and produce much better than a plant that is immature.

Getting back to the "deep winter" or Persephone Period of our production, we find it imperative to have replacement Greenhouse grown plugs on hand to replace greens that are on their second cut or are a once cut item. For example any lettuce cut during this period is taken out and immediately replaced with bok Choi, Spinach, Red Mustard, Yukina Savoy, Siberian Kale, etc.... Since the plugs are three weeks to a month old they are much more likely to get a good start and be producing more greens usually within a month. If we 'direct seed' during this period, we again open up the 'in row' seed rate so the seeds that come up have more access to light. Our deep winter direct seeding list is quite short. It consists of: Arugula, Red Mustard, Yukina Savoy, Pink Mustard Lettuce (Fedco) and Toi Sims (Snow Seed).

Some general bullet points about Winter Green Production:

1.) If possible orient your houses East to West. Better winter sun.
2.) Keep fresh air in the house! We have end wall vents open 24hrs a day unless it gets down to 18 degrees. We also don't cover the greenhouse grown greens with Covertan/Remay unless it is going to go below 26 at night. And removing the covers during the day is very important for disease prevention.
3.) Top water your original plantings but after that only use drip irrigation for keeping beds moist. Excess leaf moisture in winter can be very detrimental to all your greens.
4.) After five years of production start using "saturated media" soil tests vs conventional testing. It will give you a better picture of what is going on in your houses. Avoid over doing animal based manures and compost sources; they will only hasten the inevitable salt build up in your houses. Our nitrogen source in our greenhouses is now only peanut meal or Alfalfa Meal. No more composted chicken manure!!

5.) Remember it is the winter winds that do most of the damage to plants. It is, at least, equally important as keeping temperature sensitive plants covered during cold snaps and why high tunnel production is so effective.
6.) Our winter high tunnel production is (one house 1/2 Kale, 1/2 Swiss Chard.) (One 34X150 with five rows of:Yukina Savoy, Spinach, Red Mustard, Mei Qing Choi and Toi Sims.) (One 34X150 with six rows consisting of: Red Komatsuna, Red Choi, Joi Choi, Mei Quig Choi, JSS "Five Star Mesclun", Blue Vates Kale, Siberian Kale, Miners Lettuce, Hakuria Turnips, Spinach (Tyee and Space). We have other inflation buster tunnels with a repeat of the above but in different successions.
6.) Keep your tunnels well ventilated, preferably with a top vent in the end walls. Your goal is to keep the humidity the same in the house as it is outside. This is very important detail for disease prevention and a good reason why more growers find it justifiable to spend the extra money to have a tall profile house. Our 34X150 have the peak of the house at 16'. A low profile 17' inflation buster is a inexpensive way to grow winter greens but you will be fighting a battle with excess humidity December - March.
7.) We don't cover our greens in our house with row covers until it gets down to 28 outside temp. The second cover goes on if the outside temperature goes down to 18. And if it goes down to 10 or below we will add a third layer.
8.) Remove the row covers everyday to get the humidity out of the greens canopy. Be sure to re-cover two hours before sundown. If you wait till dark you have already lost 60% of your heat gain.
9.) Exception: If it is cloudy and cold and the interior greenhouse air temperature is still below 29, keep the covers on.

## SWD IPM: Are we there yet?

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USDA defines integrated pest management (IPM) as "a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks." Although current management of the spotted wing drosophila (SWD) is highly reliant on spraying insecticides, the degree to which insecticides are relied upon varies with each crop.

### IPM Components Currently in Use

Monitoring. A key provision of IPM is to continuously monitor pest populations. Management measures (sprays, clean harvesting, etc…) are then based on the judgment of the likelihood that a pest's population is great enough (or soon will be) to justify the treatment costs. For every crop, monitoring of SWD populations is essential. Over the past two years, we have proceeded from having ineffective traps that were not competitive with surrounding ripe fruit, to having traps that are so competitive with ripe fruit that some farmers and researchers are trying to directly protect crops by mass trapping SWD (more on this later). Although groups around the world have been striving to find ever more attractive baits and traps, the current leader for both attractant and traps are easily made. Our best trap is a 16 fl. oz. (470 ml) red cup with a tightly fitting lid, a single stripe of black electrical tape approximately one inch (2.5 cm) from the top rim, punctured with 40 one-eighth inch (3.2 mm) holes (use a hobby punch to do this) and placed in the fruit crop or surrounding vegetation with a wire hanger. The attractant bait consists of 50 – 75 ml per trap of the following recipe: water (12 fl. oz. [350 ml]), whole wheat (1 cup [240 ml]), apple cider vinegar (1 Tbsp [15 ml]), active dry yeast (1 Tbsp) and a few drops of an agricultural surfactant. For those not wishing to make traps or baits, products from a company in Spain, BioIberica, are nearly as effective as the homemade trap and bait, are more selective in trapping SWD, the bait does not spoil, and should be available on the market soon.

Use of selective insecticides. For all crops, there is a great need for selective insecticides. Selective insecticides kill SWD and have minimal effect on beneficial predatory or parasitic insects. Among the products available and registered for use in fruit crops, the most effective against SWD have been pyrethroids, organophosphates, and neonicotinoids, and spinosyns (listed by increasing selectivity). Pyrethroids and OPs have a long history of being problematic for being disruptive to crop ecology. Unfortunately, the limit on the number of applications per crop and per farm of spinosyns (Entrust, Radiant, or Delegate) means that these highly effective and selective products have to be used sparingly. Neonicotinoids have been used to a limited extent, partly because early reports from the Pacific Northwest rated them as being inferior insecticides. However, neonicotinoids work best through ingestion, and west coast researchers did not include a feeding stimulant with this class of insecticide. I have suggested combining several SWD insecticides with sucrose (table sugar) at a concentration of 2 lb per 100 gallons can enhance insecticide ingestion by SWD. Of the neonicotinoids, acetamiprid (Assail) deserves special consideration because it has much lower toxicity to honey bees than other neonicotinoids

(Belay, Venom, or imidacloprid products), and so is safer to pollinators when applied post-bloom in the crop. Furthermore, acetamiprid is highly systemic – a property not shared with other classes of insecticides available to target SWD. I observed ~80% mortality in larvae fed upon diet experimentally spiked with the amount of acetamiprid absorbed into fruit (based on IR-4 data).

Sanitation. Removal and destruction of infested fruit appears to be a practical (and perhaps essential) measure in raspberries and day-neutral strawberries. In raspberries, a two container picking system (one for overripe fruit to be discarded, one for sound fruit) has worked well. For strawberries, mashing soft berries between the rows appears to help. In all fruit crops, keeping the fruit picked cleanly, and picking when the fruit are approaching ripeness are key to preventing SWD outbreaks. PYO growers with exceptional customer traffic may not even have to spray blueberries to protect them from SWD. The acreage of some crops (especially raspberry and day neutral strawberries) needs to be adjusted to a manageable size so that fields can be kept picked. At the end of blueberry season, bird netting should be removed to allow any remaining fruit to be consumed by birds rather than to allow continued SWD breeding.

**IPM Methods requiring more research**

Mass trapping. Mass trapping is a method that removes insects by physically capturing them. Successful mass trapping depends on the following variables: effectiveness of chemical and visual attractants for bringing the target insect to the trap, the efficiency of the trap for capturing the insect, the number of traps placed per unit area, the population density of the insect, and our economic threshold. Some guesswork is needed to estimate the distance SWD are attracted to our best traps, but based upon my field trapping experience, this distance is approximately 10 m, and most responses are probably even closer. If we were to place traps 10 m apart, this translates to 40 traps per acre (100 traps per hectare). This number would be modified as various factors warrant. We could decrease the trap density if (1) the chemical and visual attractants draw flies to the trap from greater distances, (2) the efficiency of capturing the flies per trap visit is increased, (3) fly mobility (diffusivity) increases, (4) the population density is lower, or (5) the economic threshold (tolerance for damage) is increased. Historically, mass trapping has worked in the 1930s to protect sweet cherries from damage by SWD. As early season crops, sweet cherries, June bearing strawberries, and early ripening blueberries all are appropriate crops to consider mass trapping.

How well do our traps work? One measure is competitiveness of our traps when they are placed among highly competitive fruits. If the traps catch large numbers of flies, it indicates that there is the possibility that mass trapping could work, if sufficient numbers of traps are placed in the crop. In 2013, we observed excellent ability of our traps to capture flies when surrounded with ripe blueberries, raspberries, and tree fruits (apples and pears).

Unfortunately, catching many flies doesn't necessarily translate into significant reductions in the fly population or protection of fruit. High trap catches certainly signify that there is a large population that threatens the crop. The conundrum is, to know whether we may be protecting fruit requires that we have some measure of the population of flies not being captured in traps, because these flies continue to jeopardize the fruit. To get an idea of how many flies are attracted to the trap, versus the number that are actually captured and drown in the bait, I hung pairs of cup traps directly over 5 gallon [20 liter] buckets. For only one trap in the pair, I sprayed the exterior of the trap with an insecticide combination likely to cause nearly immediate knock-down and mortality of visiting insects. From this preliminary test, only about one-fifth of the SWD were captured by drowning in the bait when compared with the number recovered from the buckets. This is a sobering value, because it implies that about 14 visits of flies to traps would be required before we would see a 95% reduction in the fly population in the field. If flies have an opportunity to mate and lay eggs between visits to traps, then protection of fruit through mass trapping is unlikely. What may we do to improve upon this situation? One option is to expand the concept of the "trap" to include the surrounding vegetation and the outer surface of the trap itself. Rather than trying to achieve a 5-fold improvement in retention of flies in the trap, if we can guarantee that flies will succumb once they contact the trap or nearby surrounding vegetation, we will have achieved the same goal in reducing the fly population. There are a great number of insecticides that could be suitable for application to the surface of traps. Rapid fly response to the insecticide would be acceptable, rather than the immediate knock needed for my experiment. A broad choice of insecticides can be considered, because the limited quantity of insecticide applied to traps could make even expensive active ingredients economically practical. Furthermore, limiting insecticide application to the trap will limit the environmental impact of their use to a great degree and facilitate U.S. EPA registration.

<u>Exclusion.</u> Raspberries are so extremely susceptible to SWD that it may be economical to use high tunnels to produce and protect fruit. The research needed is not to determine whether fruit can be protected with screening – it is known that 1 mm screening (e.g., ProtekNet from DuBois, 80 g per square meter) will exclude flies from access to fruit. However, the use of insect exclusion screening along the sides of high tunnels has not been tested with respect to horticultural properties in growing the crop. Side benefits can include exclusion of birds, excluding rain to reduce fruit rot, and a prolonged growing season. Some growers are building high tunnels for cane fruit, so we shall soon learn how well they perform. Caging bumblebees inside these enclosures may be necessary for pollination, as there are open blossoms at the same time that there are ripe fruit.

*Disclaimer: Use of trade names for pesticides does not constitute an endorsement for that product. Always read and follow pesticide label directions.*

## Nourse Farms Cane Berry Harvest and Spotted Wing Drosophila 2013

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### Overview

Harvesting Primocane and Floricane Red, Black and Yellow Raspberries, and Blackberries on 14 acres.
We are detecting SWD in late June to early July with traps. Our pickers and packers usually find larva in berries before there are any caught in traps.
We now apply insecticides and fungicides on a weekly basis when berries are being harvested.
Berries are harvested every other day. All culls are removed from the field by late July or early August.
We offer Pick Your Own in July. We discontinued Fall Pick Your Own.
No customer complaints for SWD since Fall 2011!
SWD never completely go away.

### Basic Strategy

Regular insecticide applications every 5-10 days, utilizing PHI materials that are 24 hrs or greater whenever possible.
There is some indication the addition of Oxidate may help control insects.
We now apply all crop protectants after rain.
Harvest all ripe fruit from plants including culls. After August 1st all culls were removed from plantings.
Raspberries and Blackberries are harvested every other day. Our weekly pick schedule is Monday, Wednesday, Friday and Saturday. All Pick Your Own fields are picked clean prior to insecticide treatments.
Trellis and thin both summer and fall plantings.
All fruit not sold that day is cooled to 33 degrees. Maintaining cold chain is important!

### Observations

SWD trap numbers were higher near trees and other cover.
Nighttime temperatures above 65-70 degrees increases hatch interval.
Pickers and packers can identify berries with larvae when soft or juicy.
Larva are harder to detect when 2 or less per fruit.
SWD was found in Kale and Collards between 2 raspberry fields.

### Wish List

Identify materials to damage or plug breathing tubes on eggs.
Identify Trap Crops.
Understand other 'Hiding Places'.
Get 2-4 applications of Lannate per crop per year.

## 'Outside the Box' Options for SWD Management

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Native to Southeast Asia, the spotted-wing drosophila (SWD), ***Drosophila suzukii*** (Matsumura 1931), was widely observed throughout parts of Korea, and China prior to its identification in Japan in 1913. Its 1980 arrival into the United States as an invasive pest began in Hawaii, appearing in central California by August of 2008, spreading into Washington, Oregon and Florida the following year. By 2011 the SWD has become widespread, captured in Utah, Louisiana, Arkansas, Kentucky, Tennessee, North and South Carolina, Wisconsin, Michigan, West Virginia and Virginia, Maryland, Pennsylvania, New Jersey, New York and all of the New England States (Image 1). The pest has also been found in Europe, including the countries of Italy, France, and Spain. In NY the SWD flies were first captured in apple cider vinegar traps in the experimental vineyard at the Hudson Valley Laboratory in Highland late in August of 2011. Damage to small fruit was first reported by Laura McDermott, a Regional CCE Specialist in the Capital District with traps placed in late raspberry, grown organically in Ancram, NY.

The SWD female differs from other vinegar flies in possessing a unique ovipositor, capable of inserting eggs into un-ripened fruit, which gives them a biological advantage over other *Drosophila*. Thus the SWD can reproduce on fruit earlier in the season to outcompete other fly species, producing as many as 13 generations per year in Asia, with 6-9 generations predicted for NY depending on the season. Another advantage this fly has is its use of multiple hosts including *Cornus kousa*, dogwood, *Eugenia uniflora*, Surinam cherry, *Fragaria ananassa*, strawberries, *Morus spp*., mulberry, *Murraya paniculata*, orange jasmine , *Myrica rubra*, Chinese bayberry , *Prunus spp. - P. avium*, sweet cherries; *P. domestica*, plums; *P. persica*, peaches, *Pyrus pyrifolia*, Asian pears, *Ribes spp*., currants, *Rubus spp. - R. armeniacus*, Himalayan blackberries; *R. loganobaccus*, loganberries; *R. idaeus,* raspberries; *R. laciniatus,* evergreen blackberries; *R. ursinus,* marionberries, *Vaccinium spp.*, blueberry, cranberry, *Vitis vinifera*, wine grape. In NY it has been reared from The tartarian honeysuckle, *Lonicera tatarica*, is an invasive plant that also hails from Asia and Siberia. It grows along the wooded edges of agricultural crops, carrying red berries in pairs that become heavily infested with SWD by early July. In the Hudson Valley, SWD developed in very high numbers on this host in the spring of 2013, providing an ideal reproductive site for the fly to disperse to small fruit later in the month as fruit became available (Image 2). The black cherry*, Prunus serotina*, Awoodland tree species, is also a preferred wild host for SWD. This tree grows in forests and landscapes throughout the Northeast and is native to North America. On Long Island, recent observations by Faruque Zaman, Suffolk County Cornell Cooperative Extension, showed 90% infested fruit with SWD. On average, 112 adult SWD emerged after incubating 4 oz. samples of black cherry fruit in the lab. In Long Island, it appears that black cherry is the earliest wild host utilized by SWD. Pokeweed, *Phytolacca* *acinosa*, another known wild host of SWD, is found to have 80% infested fruit in late August. Fruit of these two wild hosts appear to be the most preferred in late summer and early fall, providing an additional point source of SWD along agricultural edge late into the growing season.

Over the past two years we have seen SWD spread throughout the fruit growing regions of the Hudson Valley and Lake Champlain in western NY in 26 NY counties (http://www.fruit.cornell.edu/spottedwing/dist.html). Across the Hudson Valley of NY, Suffolk County of Long Island and Hampshire County, Massachusetts, the first SWD captures occurred during the week of June 10$^{th}$. Through the use of yeast and vinegar baited traps we have observed the fly nearly one month earlier then in 2012. Traps hung on 1 May in small fruit plantings of raspberry and blackberry throughout the lower Hudson Valley captured SWD 2 weeks prior to fruit infestations. The sustained capture of SWD flies prior to egg laying provided growers with a pest management start date to initiate preventative treatment. However, under the best of pest management programs in raspberry and blackberry, following a 3 to 4 day application schedule, rain events combined with pick-your-own weekend schedules forced application delays of up to 7-days, allowing SWD to infest fruit beyond rescue. All growers in the programs monitored by the ENY Fruit Team had infestation levels exceeding 17% using the best materials under tight treatment protocols.

Given the need for very tight insecticide schedules, insecticide labeled constraints and the need for resistance management strategies, it is likely that complete control of the SWD is unlikely, even under the most diligent of management programs. The perpetual regenerations and presence of all stages of the SWD life cycle provides insulation, in the form of egg, larva and pupa within the host fruit, to escape most insecticide applications. Under the best scenario, infestations can be significantly reduced by tight management intervals, with commitment to using a 3-4 day pest management program being the essential component to success. To improve on this strategy, cultural management considerations should also be undertaken. Creating a less favorable environment for SWD reproduction should begin by maintaining an open canopy through pruning to increase sunlight and reduce humidity while improving spray coverage. Drip lines should be installed ‘in-ground’ instead of using overhead irrigation when possible. Removal of infested fruit through cane and ground sanitation will reduce SWD emergence, reducing fly populations. Harvesting frequently and completely will prevent the buildup of ripe and over-ripe fruit. Unmarketable fruit should be removed from the field and either frozen, "baked" in clear plastic bags placed in the sun, or disposed of in bags off-site, killing the larvae and preventing adult emergence. Insecticide sprays directed at the SWD adults will reduce egg laying. Begin insecticide treatments at the first SWD trap catch prior to fruit ripening. Treatments should be applied on a 3 to 4 day schedule, repeated after 1 inch of rain. During July and August the insect can reproduce quite quickly, every 10 to 14 days. Select only the most effective insecticides, rotating insecticide modes of action on a 10-14 day interval during peak flight periods.

A 2013 farm success story: SWD was first found in Orange county, NY on 10 June, 2013. A successful pick-your-own operation in that county was able to keep infestation levels down to levels below 2% through to the end of July, then below 17% to the end of the season using a 3 to 7 day spray interval (as weather and pick-your-own scheduling would allow). Management was combined with near daily picking, often clean picking on weekends reducing the SWD population potential. Products were employed in 14-day rotational scheduling beginning with Malathion, and followed using alternations of Delegate, Danitol 2.4 EC, Triple Crown and Brigade WSB. His recommendation to the consumers, upon harvesting berries, was to keep fruit cold during storage, which successfully retained fruit quality. Success in this case was not defined by achieving complete control of the pest but by achieving costumer satisfaction in fruit quality and an enjoyable farm / tourism experience.

Lab studies of fruit emersion in 1% oil (≥ 5 minutes held at room temperature (22°C)) has been shown to kill SWD eggs within the fruit (Fig. 3). Post harvest treatments employing cold temperature (1.1°C for 72 hours) significantly reduces live larva (Fig. 4). It may prove of value to small fruit growers to consider funding post harvest research to determine the viability of these approaches to SWD management.

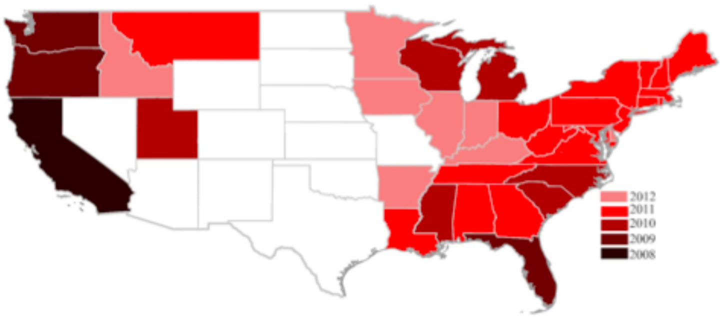


Figure 1. State level SWD in the United States. Burrack, et al. 2012. Journal of Integrated Pest Management.

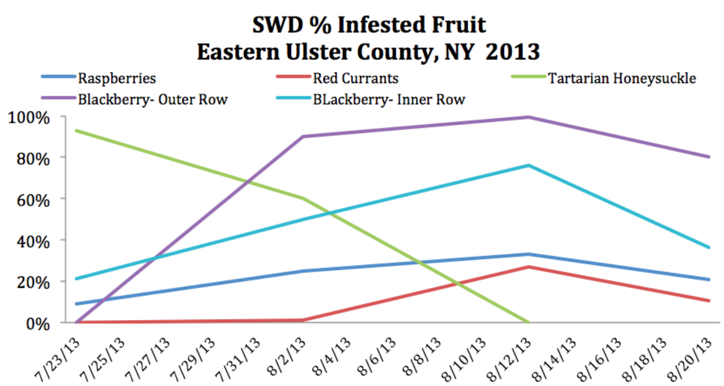


Figure 2. Chart representing field collected small fruit and the border host Tartarian Honeysuckle, *Lonicera tatarica*, from a commercial berry patch in Marlboro, NY 2013.

SWD Larva Survival in Raspberry Post 1% Oil Drench
HVLab, Highland, NY 2012

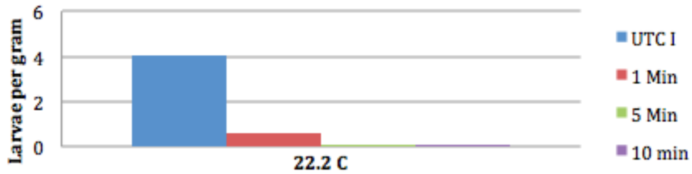


Figure 3. Post harvest evaluation of Amigo (methylated soybean oil) and temperature for controlling SWD.

SWD Larva Survival in Raspberry Post 1% Oil Drench
HVLab, Highland, NY 2012

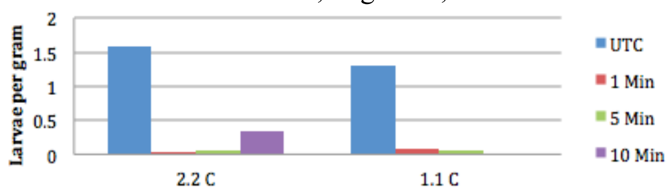


Figure 4. Post harvest evaluation of Amigo (methylated soybean oil) and 2 refrigerated temperatures for controlling SWD.

**2013 SWD Trapping Out Trials in Blackberries**

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Blackberries are one of the preferred crops of the Spotted Wing Drosophila and as such are a good candidate for trapping out trials. Traps consisted of red solo cups modified with black electrical tape wrapped around the cup near the top, and approximately 20 tiny holes poked through the tape. This trap held the apple cider vinegar-ethanol lure. In addition, a smaller cup with a mesh top was placed in the solo cup and held the whole wheat flour/yeast dough lure.

Traps were set out August 15 every 7'-10' in an untrellised organic blackberry planting. No pesticide applications were made throughout the trial. Traps were placed near the fruit –hung on the canes near the fruit or placed on the ground next to the berries on drooping canes. Lures were changed weekly and fruit was inspected for signs of egg laying and larvae.

The traps caught SWD the first two weeks (August 22 & 29), however the fruit remained SWD free. On September 5, fruit infestation was approximately 50%. One week later on September 12 there was 100% fruit infestation. This trial was deemed a failure.

Several questions were raised as a result of the trial:

- Did the trap placement so close to the fruit actually help to draw in the SWD and increase the infestation?
- Would placing traps only on the periphery away from the plants and fruit have helped to reduce or delay the fruit infestation?

**Rhode Island SWD trap-out experiment**

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Six mid to late season varieties, 11 rows at commercial blueberry planting.
Started out with dual baited trap in red cup (Apple cider vinegar plus floating specimen cup of yeast and whole wheat flour). August 7, switched to all flour and yeast bait because of Rich Cowles's findings.

**A.** Northland (5) X X X O O O X X X O O O O O O X X X O O  
**B.** Northland (5) X X X O O O X X X O O O O O O X X X O O  
**C.** Blueray (4) X X X O O O X X X O O O O O O X X X O O O  
**D.** Blueray(4) X X X O O O X X X O O O O O O X X X O O O  
**E.** Bluecrop (5) X X X O O O X X X O O O O O O X X X O O O  
**F.** Bluecrop (5) X X X O O O X X X O O O O O O X X X O O O  
**G.** Chandler (7) X X X O O O X X X O O O O O O X X X O O O  
**H.** Chandler (7) X X X O O O X X X O O O O O O X X X O O O  
**I.** Darrow (8) X X X O O O X X X O O O O O O X X X O O  
**J.** Elliot (10) X X X O O O X X X O O O O O O X X X O  
**K.** Elliot (10) X X X O O O X X X O O O O O O X X X  
Number in parentheses indicates fruiting season 1 = early , 10 = late

Treatment
X = Trap
O = Control (No trap)
9 ft between rows, 6 ft between plants
Traps set up July 3 – September 11; changed bait weekly. Collected 12 berries/bush each week from ripe varieties. Incubated at 80 F; after 7 days, counted SWD pupae & number of infested berries.

Results
Our trap-out didn't work – and statistically more SWD in blueberries with traps in some reps.

# Are Blueberries For You?

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Blueberries are native to North America, and the delicious fruit has been harvested in the wild for centuries. Blueberries belong to the same family of plants as cranberries, rhododendrons, and azaleas. They have limited adaptation to the cold winter temperatures of northern New England, but may grow satisfactorily on protected sites where the winter temperatures do not fall below minus 25 degrees F.

**Selecting and Preparing a Planting Site**

A blueberry site should full sunlight and protection from strong winds. Avoid low areas that drain poorly or are prone to early frosts. Blueberries prefer a well-drained, sandy loam soil, rich in organic matter. Heavy clay soils should be avoided, but may be made more suitable for blueberries with the addition of organic matter such as peat moss, rotted or aged sawdust, and/or compost. All perennial weeds should be eliminated from the site before planting. If necessary, grow cover crops such as buckwheat, rye, or oats on the site and plow them under for one to two seasons before planting blueberries to eliminate the weeds. Planting cover crops will also add valuable organic matter to the soil.

Have your soil tested to determine its pH and fertility status. Blueberries require a relatively acid soil for good growth. The soil pH should be within the range of 4.5 to 5.2. Soils with a higher pH may require additions of finely ground sulfur or aluminum sulfate to lower the pH. It requires approximately 1.2 pounds of ground sulfur, or 7.2 pounds of aluminum sulfate, per 100 square feet to lower the pH of a loam soil one half of a pH unit (e.g. 5.0 to 4.5). Sandy soils require only half these amounts to accomplish the same pH change. Follow the recommendations of your soil test results. Soil organic matter should be at least 4%. Organic matter levels can be increased by plowing down cover crops before planting and/or incorporating manure or compost into the soil.

**Planting**

Plant blueberries in the early spring. Healthy two- or three-year-old plants from a reputable nursery generally perform best. Younger plants, such as one-year-old rooted cuttings, tend to grow very slowly for the first two years and take longer to bear large crops of fruit. Plants older than three years are more expensive and the additional cost is usually not justified by earlier production. Space the plants five to seven feet apart in rows eight to ten feet apart. Dig a planting hole about two times the diameter of the plant root ball. Blend the removed soil with pre-moistened peat moss, compost, or rotted sawdust in a 1:1 ratio. Set the plants slightly deeper than they were in the nursery and fill the hole with the soil mixture. Do not place any fertilizer in the planting hole. Water the plants thoroughly immediately after planting. Prune out any dead, weak, or broken branches.

**Care and Maintenance**

After planting, apply a four- to six-inch layer of mulch around the base of the plants to conserve soil moisture and reduce weed growth. Coarse sawdust, woodchips, shavings, bark, pine needles, or composted leaves can be used as mulching materials. Make sure the mulch is free of weed seeds. The soil should be moist before the mulch is applied. A new layer of mulch should be applied when the old layer starts to break down.

Three to four weeks after planting, apply a small amount of a balanced fertilizer (e.g. 2 oz. 10-10-10) or one ounce of ammonium sulfate around each plant. Organic equivalents, such as bloodmeal or composted manure, may also be used. Apply the fertilizer in a circle 15 to 18 inches from the base of the plant. Use the same amount the year after planting. Each year following, increase the amount of fertilizer incrementally by roughly two to four ounces each year, using the lower rate for more concentrated fertilizer products. Fertilizer can be applied once in the early spring or, for best results, split the application, and apply one half of the recommended rate in the early spring and the other half four to six weeks later. Blueberry plants generally do not require high amounts of fertilizer. Over-fertilization could lead to excessive tender growth and increase the potential for winter injury.

The plants should be watered regularly throughout the growing season. A blueberry planting should receive one to two inches of water per week. Newly planted blueberries should not be allowed to fruit for the first two years after planting. Remove all flower clusters in the spring to encourage root development and vegetative growth. Leave a few flower clusters on the plants to produce a small crop of fruit in the third year, and plants may be allowed to set a full crop four or five years after planting.

**Pruning**
Blueberry bushes should be pruned every year to produce high yields of good quality fruit. Pruning occurs during the dormant season, usually in the late winter when the snow has receded. The object of good pruning is to maintain plant vigor and promote fruit quality. The bushes are pruned to an open habit to allow good light penetration and air movement. The time and labor commitments for pruning are considerable, but will pay off in long-term fruit quality and productivity.

**Harvesting**
Fruit begin to ripen in mid to late July and peak production generally occurs from early to mid August. Fruit is borne on clusters of five to eight berries that ripen in succession over a period of several weeks. Pick the berries only when they are fully ripe, generally one to three days after they turn blue. Be sure there is no tinge of red color on the fruit before harvesting. Blueberries work very well as a pick-your own crop, as long as customers are properly informed regarding how to pick, and are kept in rows where plenty of ripe fruit is available. Picking for the retail or wholesale market is labor intensive and costly, but prices are typically good enough in local markets to justify hiring labor for harvest.

**Pest Management**
Although blueberries are not bothered by many pest problems, it is wise to become familiar with the different blueberry pests, their life cycles, and the damage they cause. The key to good pest management is prevention. Keep your planting free of weeds. Weeds compete with blueberries for nutrients and water, and may also harbor insects and diseases.

Spotted wing drosophila has become a major pest of blueberries in New England, and can be very challenging to manage in a blueberry field. At this time, only frequent, regular insecticide sprays will prevent larvae from infesting the fruit once the fruit fly has become established in a field. Growing early maturing varieties that ripen before the fly populations build to damaging levels can greatly reduce the amount of effort required to manage drosophila, but will shorten the fresh market season for growers

Another common insect problem in blueberries is the blueberry maggot. This is the larva of a small fly that feeds inside the developing fruit. It also can be managed with appropriate insecticide sprays applied when the fruit start to color.

The most common disease problem for blueberries is mummy berry. This is a fungus that causes the fruit to shrivel and turn hard. It may be managed with fungicides applied in the early spring, or by vigilant removal of all the infested fruit ("mummies") from the planting every year to prevent new infections. Several varieties are resistant to this disease, including Jersey and Blue Crop.

Birds are a serious pest of blueberries. Covering the plants with netting is the most effective control. Plastic or cloth netting is available through agricultural equipment dealers. It is best to use a post and wire frame to support the netting over the plants.

**Bottom Line**

The cost of establishment of a highbush blueberry planting is thought to be in the range of $5,000 to $8,000 per acre, depending on how much equipment you already own, labor costs, etc. The annual gross returns once the plants come into full production (4 to 6 years) should be in the range of $12,000 to $16,000 per acre with a net return of $5,000 to $8,000 per acre, assuming yields of 5,000 to 8,000 lbs. of fruit per acre and a sale price of around $2.50 per pint.

Blueberries can be a profitable crop in New England, if managed properly. Although establishment costs are relatively high and there are significant potential pest problems that will have to be constantly and consistently monitored and managed. In most areas demand for blueberry fruit is high and customers are happy to purchase them as a pick-your-own crop or as pre-picked fresh retail at farm stands and farmers markets.

**Blueberry Varieties for New England**

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Several new blueberry varieties have been released in the last decade and even more may become available in the next ten years. This is good news for growers because more choices are available, but choosing the best varieties for your location is challenging because we do not know as much about newer types as older varieties.

A primary need for New England sites is winter hardiness. New England ranges in USDA hardiness zones from 7a (0 to 5 $^{o}$F minimum) along coastal regions in southern states to 3b (-35 to -30 $^{o}$F) in northern interior locations. Most northern highbush blueberries do best in USDA hardiness zones warmer than 5b. Zones 5a or colder may result in periodic winter injury. In very cold locations growers may have success with half-high blueberries. These are hybrids of highbush blueberries (*Vaccinium corymbosum*) and lowbush blueberries (*Vaccinium angustifolium*). Plants are shorter (2 to 5 feet tall) but more hardy than most highbush varieties. Remember that minimum winter temperatures (hardiness zones) do not fully predict variety performance. For example, colder locations also tend to have relatively short growing seasons, and blueberries do best with more than 160 frost free days. Local topography also influences the likelihood of winter and spring cold damage. Once you have identified varieties that should tolerate your climate, you can begin to narrow your choices based on other traits, such as productivity, fruit quality, harvest season, and disease tolerance.

Descriptions of varieties that should do well in much of New England are given in Table 1. To narrow your choices, learn what your state's Extension service recommend and, if possible, what varieties have performed well for other growers in your area. Make sure to consider varieties that are adequately hardy for your location. We have also included descriptions of newer varieties. These are recent releases that have not been tested adequately to recommend, but should be trialed on a small scale.

<u>Early-season</u>

'Duke' is the best early variety for warmer areas, and has replaced older types such as 'Earliblue' and 'Bluetta' in most areas. It is high yielding and produces large firm fruit that store well, have a nice mild flavor and can be machine picked. It is less hardy so may not do well in zone 5 or colder. 'Bluejay' is another good choice for warmer areas, although yields can be inconsistent. Berries have excellent overall quality and bushes are upright growing and harvest well mechanically. 'Northland' and 'Patriot' are two older very hardy types for cold areas. They grow about 4 feet tall, and are very productive but berries are soft. 'Northland' is earlier than 'Patriot' but berries are small and darker in color. 'Patriot' produces larger berries with a nice flavor. 'Polaris' and 'St Cloud' are two other hardy half-high types that mature in the early season and produce firmer fruit than 'Northland' or 'Patriot'. Polaris fruit are large and flavorful Bushes can grow to about 4 feet tall.

Newer early-season types that show promise include 'Blueribbon', which was released by Fall Creek Nursery in Oregon in 2012. Blueribbon matures between Duke and Draper and reportedly has high yields and exceptional flavor. Blueribbon is expected to be about as hardy as Legacy, which would be a problem in most of New England. 'Sweetheart' was developed in

New Jersey (2011) as a very early type with good firmness and superior flavor, but fruit may be somewhat small, variable in color and soft. Huron was developed at MSU (2009) as an early midseason type (between Duke and Draper) that appears hardier and a more consistent producer than Duke, with medium to large flavorful berries. Like 'Duke', 'Huron' blooms late to avoid spring frost damage.

<u>Mid-season</u>

There are several excellent varieties to choose from in this season. 'Bluecrop' is still worthy of planting in warmer locations. It is very high yielding, with large berries, acceptable flavor, but at short storage longevity. The bushes are moderately hardy, 4-6 feet tall and somewhat spreading. 'Draper' is a newer variety that ripens a little before 'Bluecrop'. The strength of 'Draper' is fruit quality. Berries have excellent flavor and firmness, and store for a long time. 'Draper' can be machine harvested. The bushes are somewhat slow growing and less vigorous than most varieties, but appear to be as hardy as 'Bluecrop'. 'Sierra' and 'Toro' are good mid-season types for warmer New England locations.

Mid-season types to consider for cold locations include the highbush 'Blueray' and the half-high 'Chippewa'. 'Blueray' is hardier than 'Bluecrop' and productive, but berry quality is not as high and the bushes produce many canes and take extra time to prune. 'Chippewa' is very hardy and grows to 4-5 feet. 'Superior is a newer (2009) half-high from Minnesota that matures in the late mid-season. It is very hardy, with good fruit quality and grows to 5 feet tall.

New mid-season types include 'Razz' (New Jersey, 2011) and 'Top Shelf' and 'Clockwork' (Fall Creek Nursery, 2012). Reports indicate 'Razz' is a reliable producer with medium to large fruit. Berries have average firmness and may not store well. The name relates to the flavor, which has raspberry overtones. Hardiness of 'Razz' is not known. 'Top Shelf' and 'Clockwork' ripen with 'Draper'. 'Top Shelf' is meant for hand picking and has excellent size and flavor ('Draper' is a parent). 'Clockwork' was developed for processing because berries are smaller and ripen all at once for machine picking. Hardiness of 'Top Shelf' and 'Clockwork' is not known but based on their parentage, they are expected to be similar to 'Legacy'.

<u>Late season</u>

Some varieties to consider for the late season, in order of ripening. include 'Nelson', 'Jersey' 'Legacy', 'Liberty', 'Elliott' and 'Aurora'. Nelson has excellent overall quality but is a little less hardy so yields have been site specific. Jersey is a reliable hardy producer but berries are small and soft. 'Legacy' is a very productive, high quality variety that matures with Nelson but has a long picking season. Hardiness is limited; 'Legacy' will do well only in the mildest New England locations. 'Liberty' is a newer type that ripens a little before 'Elliott' but has much better flavor and storability. 'Liberty' should do well in warmer locations. Elliott is very late maturing and extremely productive, and as hardy as Jersey, but berries have marginal flavor. 'Aurora' is the latest variety available. It is as hardy as the other late types and productive. Berries are somewhat tart.

Two new late-midseason types released by Michigan State University in 2013 are 'Osorno' and 'Calypso'. 'Osorno' has yielded very well in various locations and has exceptional fruit quality. 'Calypso' also has shown high yields and quality in diverse test locations. 'Osorno' and 'Calypso' are hardier than 'Legacy', but may not do well in very cold sites. Fall Creek Nursery just released 'Cargo' for fresh and processed uses. 'Cargo ripens a little before 'Elliott' and has a mild, tart flavor. 'Cargo' is expected to be about as hardy as 'Legacy'.

| Table 1. General characteristics of blueberry varieties. | | | | | | |
|---|---|---|---|---|---|---|
| Cultivar | Season[1] | Hardiness[2] | Yield potential[2] | Fruit quality | | |
| | | | | Size[3] | Firmness[2] | Flavor[2] |
| Aurora | VL | *** | **** | M | **** | ** |
| Bluecrop | M | ** | *** | M-L | *** | *** |
| Bluejay | E-M | ** | ** | M | **** | *** |
| Blueray | M | *** | *** | L | ** | ** |
| Bluetta | E | *** | ** | M | * | ** |
| Bonus | M | * | ** | VL | ** | *** |
| Chippewa | M | **** | ** | M | *** | *** |
| Draper | E-M | *** | *** | L | **** | **** |
| Duke | E | ** | **** | L | **** | *** |
| Elliott | VL | *** | **** | M | **** | * |
| Huron | E-M | *** | *** | L | *** | *** |
| Jersey | M-L | *** | *** | M | ** | *** |
| Legacy | M-L | * | **** | L | **** | **** |
| Liberty | L | *** | *** | L | **** | **** |
| Nelson | L | *** | *** | L | **** | **** |
| Northblue | E-M | **** | ** | M | ** | ** |
| Northcountry | E-M | **** | * | VS | * | **** |
| Northland | E-M | **** | **** | M | * | ** |
| Northsky | M | **** | * | VS | * | *** |
| Patriot | E-M | **** | **** | L | ** | **** |
| Polaris | E | **** | ** | M | *** | **** |
| Rubel | M | *** | ** | S | ** | *** |
| Sierra | M | ** | ** | M | *** | *** |
| St. Cloud | E | **** | ** | M-L | ** | **** |
| Superior | M-L | **** | | | | |
| Toro | M | *** | *** | L | *** | *** |

[1]E = early, M = mid-season, L = late
[2]Attribute increases with * number
[3]Size ratings very small (VS), small (S), medium (M), large (L), and very large (VL).

**Pruning Blueberries**

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Blueberry bushes should be pruned every year during the dormant season (January through March). Good pruning practices promote higher fruit quality, earlier ripening, and reduces the likelihood of fruit rots.

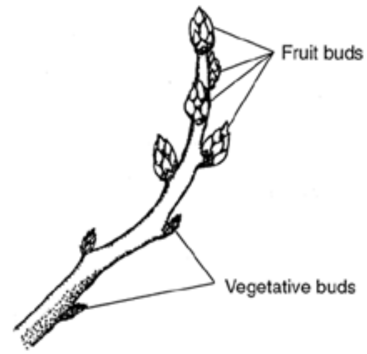


**Figure 1. Types of buds on a blueberry shoot**

For the first two years after planting, simply remove any dead branches and all weak, spindly growth. Do not over prune young bushes because this can slow the development of a strong root system and plant crown. A productive, well-managed blueberry plant should have eight to twelve healthy, vigorous, upright canes which range in age from one to six years old. To achieve this follow the steps below for all plants that have been established for three years or more.

A short video demonstration of blueberry pruning is available online from the University of Maine Cooperative Extension. It can be seen at this website: http://www.youtube.com/watch?v=fm6ZfpGy5oQ

1. Prune out any weak, low-growing or diseased canes.
2. Prune out any canes that are more than six years old (these are usually the thickest canes, which are gray in color with peeling bark). Blueberry canes tend to be less productive once they are more than six years old and should be pruned out in favor of younger, more productive canes. Cut the old canes back to ground level unless new cane growth has been sparse; in which case, leave a four- to eight-inch stub above the ground. New canes may sprout from these stubs.
3. Thin the remaining canes, leaving those with the most vigorous shoot growth (long, thick branches with good fruit buds). Leave six to eight vigorous two- to five-year-old canes and three to four one-year-old canes per bush. A mature blueberry plant should have eight to twelve healthy canes varying in age from one to six years old.
4. Remove any weak fruiting branches on the remaining canes, especially those less than six inches in length. Most fruit is produced on vigorous one-year-old shoots on healthy two- to five-year-old canes. The fruit buds on these shoots are large and teardrop-shaped. Each bud will produce a cluster of five to eight flowers. The shoots also have smaller, pointed vegetative buds that will produce leaves (Figure 1).

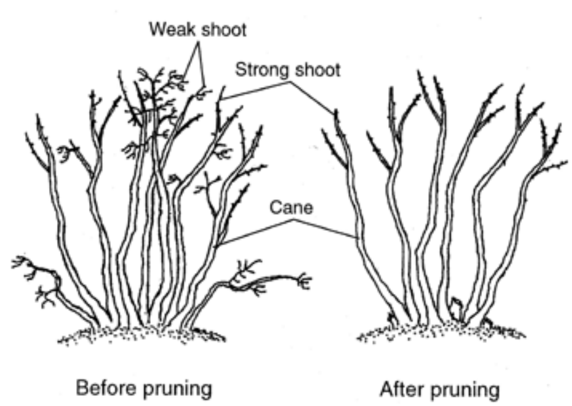


**Figure 2. Dormant blueberry pruning**

Old, neglected bushes that have not been pruned for years can be renovated by pruning out a quarter to a third of the oldest canes (tallest, thickest) per year during the dormant season, for each of the next three to four years. In this way, by the end of four years, all of the old canes will have been removed while new canes have had four years to become established and productive, providing continued harvest during the renovation process.

**Blueberry Insect Pests 101**

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For the past three years, spotted wing Drosophila (SWD) has been the most serious blueberry pest and will continue to plague blueberry growers until good control strategies are developed. Pest management decisions for other blueberry pests will be influenced by SWD control decisions. I'll cover other insects first and then return to SWD.

The first step to blueberry insect control is being familiar with potential pests and their life cycles, and knowing when the crop is susceptible. Scouting for insects is essential and may include using insect traps for some insects. Every grower should own a copy of the New England Small Fruit Management Guide, available from Cooperative Extension in all New England states.

**Scale** insects can be found year-round on blueberry canes. In the winter, scout for Putnam and lecanium scales and prune out infested canes. Dormant oil applications can help control scales.

**Winter moth** caterpillars have become a problem in eastern Massachusetts and Rhode Island. Areas not currently infested should be monitored for the small, green inchworms, but no control is needed at this time. Scout surrounding maple trees for typical winter moth foliar damage. Once winter moth is in your area then you can be concerned with controlling it. In winter moth-infested areas, an insecticide should be applied when winter moth eggs begin to hatch and again about 10 days later. Buds and flowers should be monitored for developing larvae since additional insecticide treatments may be necessary. Additional sprays may be needed in blueberry plantings where winter moth populations are extremely high.

**Cranberry fruitworm** caterpillars are found within developing and ripening berries. Caterpillars are ½ inch long and mainly olive-green in color. Larvae will consume 3-6 berries, filling them with frass, and tie together fruit with silk. When damage is severe, treat the following year with insecticide at petal fall and again about 10 days after petal fall. Fruitworms are active for about 5 weeks, so they cannot be controlled with only one spray. In small plantings and light infestations, handpick infested berries. Eliminating weeds help reduce cranberry fruitworm overwintering sites.

**Cherry fruitworm** caterpillars are also found within developing and ripening berries. The orange-red caterpillars grow to ¼ - ½ inches and consume two berries as they develop and these berries are generally joined by silk. Treatment is the same as for the cranberry fruitworm.

**Plum curculio** infestations are more abundant when blueberries are planted near fruit trees. The weevil lays eggs in developing berries and the larvae feed, causing infested berries to drop prematurely. Plum curculio larvae (grubs) are grayish-white, C-shaped, legless and have brown heads. Insecticide sprays, other than Bt products, applied at petal fall and first cover (7-12 days later) will likely control plum curculio.

**White grubs** are the larvae of various beetles that feed on roots of blueberries and other plants. White grubs feeding on blueberry roots in New England are primarily Japanese beetles, rose chafers, Oriental beetles, Asiatic garden beetles, and June beetles. Feeding by white grubs reduces plant vigor and can eventually kill blueberry bushes. Growers should check new sites for white grubs before planting and control if necessary. Established plantings infested with white grabs can be treated by drenching soil with Admire insecticide. Beneficial nematodes may be effective in controlling white grubs in the soil.

**Blueberry tip borer** moths emerge shortly after bloom and lay eggs on new blueberry shoots. The larvae tunnel into shoots and feed inside the shoot, causing shoots to wilt, arch over, become discolored, and eventually turn brown. By autumn, larval tunnels may extend 8-10 inches before larvae pupate. Manage tip borers by pruning out and destroying damaged canes.

**Blueberry maggot fly** adults look similar to house flies with a dark W pattern on each wing. In late June or early July, female BM lay eggs inside ripening berries. Eggs hatch into white, legless larvae and feed inside the fruit causing berries to become soft and unmarketable. BM adults can be monitored with red sticky spheres or yellow sticky rectangle traps baited with ammonium acetate. In small plantings, it may be possible to trap-out BM with sufficient traps. Sticky traps should be hung on a stake or on an upper branch on the south side of a blueberry bush in a perimeter row. Clear enough foliage from around the trap so leaves don't stick to it. To be most effective, yellow rectangular traps should be placed with the yellow sticky surface directed downward in a V-orientation. Check traps twice each week and apply insecticide 7-10 days after first trap catch. Repeat every 10 days through harvest, minding pre-harvest intervals on labels.

While scouting in blueberry plantings, numerous caterpillars may be encountered. **Yellownecked caterpillar, redhumped caterpillar, and gypsy moth** caterpillars are occasional pests and can be controlled with applications of Bt (Bacillus thuringiensis).

**Spotted wing Drosophila** (SWD) are Asian vinegar flies that have invaded all blueberry growing regions of North America, first arriving in New England in 2011. Female SWD have saw-shaped ovipositors that allow them to cut into healthy berries to deposit an egg. Each SWD female is capable of laying 300 eggs and there are many generations per season. Each generation takes about 14 days, depending on temperature.

SWD are being monitored in each state with various traps baited with apple sider vinegar and/or yeast-based baits. Traps appear to be most helpful in determining when SWD are first active in a region. In 2013, SWD were first caught in traps starting mid to late June in southern New England and starting early to mid-July in northern New England. Unsprayed blueberries will become infected, but probably not until after the early season varieties have been harvested. In RI, blueberries were harvested from URI's research plot from June 27 to July 18 with no SWD detected. Berries harvested later had SWD, with 75% of berries infested by August 1. SWD populations continue to build until a frost, so late varieties are more at risk than earlier varieties.

Many universities and growers are researching SWD. Small planting may be protected from SWD with small-mesh netting, but at this time the best control strategy is insecticide applications. Using different classes of insecticides, applications are needed every 7 days starting when SWD begin attacking blueberries, probably 3-4 weeks after early blueberry harvest season begins. Rain washes off insecticide and so applications may be needed more frequently than every 7 days. Adding 2 pounds of white sugar per 100 gallons of spray material encourages

SWD to feed and be killed by insecticide. Advanced planning is essential so label preharvest intervals and maximum allowed pesticide rules are followed.

Some organic and no-spray growers have successfully grown blueberry crops. Blueberries must be harvested thoroughly and often. Consumers must be encouraged to refrigerate or freeze their berries as soon as they get them home.

**Virus and Virus-like Diseases of Blueberries**

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Highbush blueberries are afflicted with numerous virus and virus-like diseases. Virus diseases are especially problematic because they are brought into a field on infected plant material and the virus can be spread via insect vectors. The virus can be present in the plant without causing symptoms while replicating and spreading itself throughout the plant for several years until symptoms are finally visible. There are no chemicals that can be sprayed to control virus diseases and once an infection by a virus becomes systemic in the plant, it is there forever and the plant must be removed and destroyed.

Six virus or virus-like diseases most likely to be found in New England have been chosen for detailed description – Necrotic Ringspot, Tomato Ringspot, Red Ringspot, Scorch, Shock, and Mosaic. Five other diseases will be mentioned, as they might possibly be observed in rare instances – Shoestring, Leaf Mottle, Fruit Drop, Necrotic Ring Blotch and Bronze Leaf Curl. For the purposes of this discussion, only the symptoms of the different diseases will be described, and management strategies will be discussed during the oral presentation.

*Necrotic Ringspot*. Affected leaves are often misshapen, crinkled or cupped downward and have small necrotic spots. The necrotic spots may fall out, creating a shot hole effect. Small twigs may also show small necrotic areas. Leaves that do not show necrotic spots may be small and rosette. In some cultivars, a severe stem dieback may occur. Infected bushes of all cultivars show a steady decline in productivity and may die eventually. The virus (Tobacco Ringspot Virus) occurs in a wide range of herbaceous and woody hosts. The disease is spread by the dagger nematode.

*Tomato Ringspot*. The intensity of symptoms varies significantly among blueberry cultivars. Infected leaves are often cupped and malformed, with circular spots. Young leaves may be strap-shaped and mottled and confused with shoestring. Necrotic spots may occur on infected canes. Infection is rarely uniform within a plant. Some shoots may be defoliated, others may have necrotic leaves, and still others may appear normal. Fruit production and quality are reduced in infected plants. Diseased plants may be defoliated by mid-harvest, and infected plants may eventually die, succumbing to winter injury. Symptoms of Tomato Ringspot are similar to those of Necrotic Ringspot. The two viruses are readily distinguished by the enzyme-linked immunosorbent assay (ELISA). It is also spread by dagger nematodes.

*Red Ringspot*. Stems often develop red ringspots or red blotches that are roughly circular in outline. Reddish circular spots appear on older leaves in midsummer to late summer. Younger leaves usually remain symptomless. The powdery mildew fungus can cause similar symptoms, but the fungus-induced leaf spots are prominent on both sides of leaves and tend not be circular. The virus-induced red ringspots can coalesce, causing the leaves to appear prematurely red in late summer and early fall. Circular, light-colored areas of blotching may develop on affected fruit of some cultivars. Aphids or mealybugs are possible means of transmission of the pathogen.

*Scorch*. Symptoms vary depending on strain of the virus as well as plant cultivar. Symptoms range from complete necrosis of flowers and leaves, which eventually leads to the death of the bush in some cultivars, to symptomless infection that does not cause significant yield loss in other cultivars. Flower and leaf necrosis may be combined with marginal leaf chlorosis. In the Pacific Northwest, the scorched blossoms often are retained throughout the summer. In severe blossom blight, the twigs will often die back. On the East Coast, an 'oak leaf' line pattern often appears on the leaves in early fall and blossoms are not retained. Infected plants generally decline each year and eventually produce little or no fruit. There is a latent period of one to two years between infection and the expression of symptoms. Symptoms usually appear on one or a few branches and progressively spread to affect the entire bush in subsequent years. Affected bushes show symptoms every year, but severity can vary considerably from year to year. Any of several aphid species may transmit the virus with differing efficiencies.

*Shock*. A complete flower and leaf necrosis of the bush during the bloom period may occur, very similar to scorch symptoms. Affected young leaves wilt, with blackened veins and black streaks down the petiole, or they blight to an orange color. Blighted blossoms and leaves drop, resulting in completely defoliation. As the season progresses, the plants appear to recover as a second flush of leaves is produced. By late summer, these plants appear normal except that they produce little or no fruit and prior to harvest they may appear more vigorous than adjacent healthy plants. The severe symptoms only develop once on a given bush or part of a bush. In some cultivars, bushes may exhibit a red leaf spot symptom the year following the severe shock reaction. Leaves that do not blight are often slightly chlorotic, with thin red ring spots. It is common for bushes in the field to exhibit symptoms for two years and in some cases even three years. However, in such cases any one part of the bush only develops the severe shock reaction once. It is suspected that this virus is spread via pollen

*Mosaic*. Symptoms on foliage include mild to brilliant mottle and mosaic patterns of chrome yellow, yellow and yellow-green. Occasionally, leaves may display areas of pink coloration. Symptomatic shoots may develop erratically throughout the bush. Mosaic symptoms are not produced every year and presumably depend on specific environmental factors especially sunlight intensity. Fruit will ripen later than usual. It is not known how the virus is spread.

*Shoestring*. This disease causes a very slow decline in the bush with low yields. The most reliable symptom is elongated reddish streaks on current-year and one-year-old stems. During the blossom period, flowers on infected bushes exhibit pinkish to reddish corollas. Infected leaves are elongated or strap-like (shoestring). Some leaves may show a red oak leaf pattern on the leaf blade. Some leaves may be crescent shaped and partially or entirely reddened. Fruit does not ripen normally and remains reddish purple instead of turning blue. The virus is spread via aphids.

*Leaf Mottle*. Leaves show a mottled pattern and may be malformed. In some cultivars, the leaves may be small in a rosetted pattern. The virus is spread by planting infected material and via infected pollen.

*Fruit Drop*. Plants affected with fruit drop disease show a reddening of the young leaves early in the season and a candy striping of the corolla similar to shoestring. After flowering, the young leaves lose the red coloration and the bushes appear normal. Approximately three weeks prior to ripening, the fruit turns blue and drops from the bush. Prior to harvest, affected bushes can be seen from the edge of the field since the branches, not having any fruit, are upright and the bushes appear taller than neighboring bushes that are laden with fruit. Affected bushes grow more vigorously than fruiting bushes, presumably because they are allocating fewer resources to fruit production and more to vegetative growth. No vector has been identified in the spread of the disease.

*Necrotic Ring Blotch*. Necrotic rings on leaves can progress to complete defoliation of the bush. Most of the information on this virus comes from rabbiteye blueberries. An eriophyd mite is suspected as the vector. Very little is known about this disease.

*Bronze Leaf Curl*. This is a relatively new disease and much is not known. Leaves turn a mottled bronze color with upturned leaves the entire circumference of the leaf. Symptoms may take several years to develop. Aphids are suspected as vectors of the virus.

**Update on Plastic, Polycarbonate, Acrylic and Glass Coverings**

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The covering on a greenhouse or high tunnel allows us to provide an environment that enhances plant growth. The main purposes are to allow light energy through and to restrict heat from escaping. It also provides some wind protection.

The amount of light energy that is transmitted through a covering depends on the type of material, orientation and location of the greenhouse or tunnel and the structural design. A comparison of covering materials is usually measured in photosynthetically active radiation (PAR). This includes the light spectrum that our eyes see.

What materials are being used to cover greenhouse/high tunnels?
A recent survey by the National Greenhouse Manufacturers Association showed that for new construction:
10% of are covered with glass,
10% with acrylic,
30% with polycarbonate
46% with polyethylene film

The following are some observations of changes that are affecting the glazings being used.

**Glass** – Wide pane, tempered glass is standard today. Sheets as large as 6' x 12' can be manufactured and placed on a greenhouse. Aluminum bars with EPDM rubber gaskets are used to seal the edges. The long life and high transmittance are an advantage for high light crops, such as tomatoes, cucumbers and peppers. Except for institutional greenhouses, most glass is used in gutter-connected structures. I don't know of any double pane glass that is being installed. Most glass has one or more energy/shade screens underneath to reduce heat loss.

**Acrylic** – Available in single thickness corrugated and double wall flat sheets, most of this material is now is modified with a percentage of polycarbonate or other plastic to give it better strength and a higher fire rating. The warranty life has now been extended to 30 years. It is available in 8 and 16 mm thickness and in 4' and 6' wide sheets.

**Polycarbonate** – This is the most common semi-rigid material applied to growing structures. It is available in corrugated single wall material and 8 mm and 10 mm double wall material. Warranty is 10 years or longer. Fire and hail ratings are excellent.

**Polyethylene sheets** – This is a semi-rigid double-wall material similar in design to polycarbonate (Solexx). It is available in 3.5 and 5 mm and requires more support to keep it from sagging. The material is white with a light transmission of 70 – 75% and used mostly in garden centers or for low light plants. Useful life is about 10 years.

**Fiberglass** – This once popular covering is no longer being used. It has been replaced by the stronger polycarbonate material. Besides the wearing of the plastic exposing the fibers, it has a high burn rate increasing insurance costs.

**Polyethylene film**– This is still the most common covering due to its low cost, ease of application and good life. Advantages include good weathering, several available thicknesses, additives such as condensate control and infrared heat inhibitor. The condensate control keeps the moisture in a film rather than droplets that drip onto the plants. Infrared inhibitor is installed as the inner layer and reduces heat loss at night by 10 – 25%. For windy locations a woven poly, such as Solarig may be a better choice. It has more tear resistance.

Recent advances in polyethylene include photoselective properties and ultra violet blocking. To date film plastics have been made as three-ply construction with different properties in each layer. New technology is now available to do 5 or 7-ply construction. This allows additional properties to be added. TIF (totally impermeable film) is being applied for soil fumigation. As there are no emission losses, the rate of application can be ½ of that of regular film. This same technology is being researched to use layers with different colors that will repel insects. It may also be developed to allow the outer layers to be removed when they become dirty or weathered. For example weathered poly has as much as 10% less light transmission than new poly. Another application may be to have a poly with a tougher outer skin.

Light diffusion is another property that has recently been added by manufacturers. This increases the amount of diffused light that reaches the plants, reducing scorching and increasing light to lower leaves. It is especially important with crops such as tomatoes, cucumbers and peppers. Research has shown that diffused light also reduces fungal spore development and insect propagation.

**Single or double layer poly** – for normal high tunnel operation, a single layer is adequate. If you are growing early in the spring or late into the fall and are providing supplemental heat, an inflated double layer is better. It reduces heat loss at night by about 40%. It also reduces the stress at the attachments and the rippling of the plastic on a windy day. Air inflation at ¼" water static pressure is best. A small blower with 100 – 200 cubic feet/minute output is needed. Connect the blower inlet to outside air to reduce moisture build-up between the layers.

**Plastic failure** – early failure of poly can be attributed to stress as noted above, abrasion on rough surfaces and sharp edges or heat build-up in that area of rafters, purlins and extrusions. Contact with chemicals from pesticides or pressure treated lumber can also affect the life of the plastic. Poly that is left on the tunnel during the winter is subject to cuts from blowing ice especially if there are multiple tunnels adjacent to each other. A scrim reinforce poly may be desirable in this situation.

**Automation To Save Labor In The Greenhouse**

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This might be better titled "Technology to Save Money In The Greenhouse". If it's a given that we all want to produce the best possible crop of the highest quality, then I think we can assume that our next goal would be to spend the least amount of money in doing so. That way we will have more cash to spend on assorted farm toys like weird seeders and additional tractors and occasionally something for the house. There's not too much we can do about constantly rising seed and fertilizer prices so we have to look at areas that demand the most of our hard earned cash. For our farm, that would be the two-headed monster Energy-Labor.

Since we are committed to paying a livable wage, we have to instill in our crew the idea that we need to have more money coming in than going out. It's the American way. Since it's also a given on our farm that we are going to make more and easier profit from our 22 greenhouse structures than the meager existence we eke out from our 30 acres of fields, we tend to spend more for technology in the greenhouses. There are two major labor saving devices that we have been using for a number of years that have helped us immensely.

The first is the SB02 bale breaker/soil mixer/ pot filler from SB Machinerie in Canada and now distributed through Ball Horticultural. We have 3 of these machines, two for flower production and one for organic vegetable plant production. If you've ever mixed peat, compost, vermiculite, perlite and water together for unending pots and flats, you'll appreciate that we can load and mix 4 bags of McEnroe light potting mix with water in under two minutes. That's a great machine in itself but we can also fill 32 1020 flats in 10 to 15 minutes depending on the operator and assuming the trays are stacked and ready to go. This machine has been the best labor saving investment I have ever bought. There are other companies producing similar machines or a series of machines that accomplish the same end but they are generally more expensive and take up a larger footprint in the greenhouse or potting shed. We have opted for the model without the conveyor so the machine can be more flexible and require just one operator. You can check out SB Machinerie's full line at: http://www.ballhort.com/Growers/_bigbluemachine.aspx

The second most important labor saving investment for us has been the Punch 'N Grow Machine, also from Ball Horticulture. While it sounds like a good way to get out some of your springtime production tensions, the machine is actually a hand-operated device from Holland developed in the United States by Tagawa Greenhouses. Young plant starts are grown in special "punchable" trays or you can buy the trays and start your own plants. This is a transplanting device that can be operated by one person but we use two people for greater efficiency and speed. While a good greenhouse worker can usually transplant and picture tag 10 to 15 48 cell 1020 trays per hour, two people on the Punch 'N Grow can do 120 trays per hour. You can fill a 30' by 96' hoophouse with 1500 flats easily in two days. The punchable plug tray varieties are limited so you may not find this system ideal for you, but if you do lots of the Top Ten flowers like impatiens, pansies or marigolds, you can save many hours of labor. You can view more on the Punch 'N Grow system here: http://www.ballhort.com/Growers/_howtouse.aspx.

There are many more labor and energy saving systems in use at our farm including computer controls, weather stations, text alarm systems and energy curtains from Wadsworth Greenhouse Supply, Posi-Clasp Roll-Lock and gear cranks from Advancing Alternatives, irrigation supplies and controls from Brookdale Fruit Farm, HAF fans from Priva in Canada, high and low temperature alarms from Thermalarm, fertilizer injectors from Chemilizer (work great with organic materials), and numerous other do-dads that we have experimented with over the years. We also bought a good, used scissor-lift that saves lots of ladder time in maintaining roof vents and repairing structures.

These improvements have helped us become more efficient and profitable at what we do. Each farm will have their own special needs and requirements but every farm has to be concerned with the rising costs of labor and energy. You can raise your prices but you also have to temper that with reductions in costs so as not to price yourself out of your market. There are a lot of bright, young farmers coming along with some great ideas and "us old-timers" need to stay focused and ready to adapt to the new technologies that can help our farms stay profitable. If I've learned one thing in 40 years of farming, it's that the quality of your crop is directly related to the learning you've acquired and put into it. Technology contributes greatly to that product quality.

## Heating A Greenhouse with Wood Pellets and Corn

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**Summary:** Intervale Community Farm installed a 165,000 BTU biomass furnace in our transplant house in 2009. While initially we had some kinks and technical problems, ultimately it has become a predictable heat source that allows us to rely on biomass for about 80% of our heating needs in the March-May season. We burn both corn and wood pellets, each of which has its advantages and disadvantages. Overall, the cost of the unit, fuel, and labor are pretty close to that of propane at the prices we pay for fuels. The primary benefit of the furnace is that it has allowed us to move to a more sustainable and locally-derived fuel source; the primary disadvantage is more time, fussing, and less reliability than our propane furnaces.

**Why Biomass?** We moved to biomass heat after receiving the results of an analysis of the farm's energy use. Looking at the results, we found that a huge percentage 40% +/- went to one activity, heating the transplant greenhouse. At the time we were running biodiesel in our tractors, and were looking to use more sustainable sources of energy. We also had been feeling the upward trend in propane prices, and noticing that all of the info out there suggested that both wood pellets and shelled corn were commonly available at a much lower cost per BTU.

With those two considerations in mind, the biomass greenhouse heat seemed like a good option, and was made more attractive by a cost-share program through UVM Extension.

**Hardware:** Our greenhouse is a fairly standard 30'x96' pipe frame inflated poly structure, which we typically start up in early March and shut down the heaters at the end of May.

We installed an LDJ 620-10 Amaiz-ing Heat 165,000 BTU biomass furnace, on recommendation of other growers and technical professionals. At the time, the LDJ was the least expensive and easiest-to-use option readily available that other growers had some experience with. Ours is a natural draft unit designed for residential use, which we sited at one end of the greenhouse. Double and triple wall 6" metal chimney pipes straight up through the roof.

On the good advice of another grower, we removed only one of our two 175,000 BTU propane unit heaters when we installed the LDJ. While we knew we'd need the extra BTU capacity provided by a second heater during cold nights, we didn't realize we'd want the propane as a backup for warmer conditions.

**Cost:** The LDJ furnace itself cost around $4600, with about $400 in electrical and $1500 in chimney pipe and fittings. The chimney would have been $300-400 cheaper if I hadn't done it a first time with single wall pipe and then had to replace it. We spent another $300 a couple of years later to purchase a beefier auger that the company made to better handle the load of nearly continuous burning, something not designed into the residential unit. The original auger twisted in half one cold night in April. It appears that LDJ units aren't wildly more expensive now; web listings have them around $4900 plus freight. Wood pellets run $275-310 per ton in bags, corn for us is $300/ton in bags.

**Fuel:** Corn is often a little cheaper than wood pellets, and with a higher BTU per ton, so we get a bit more heat out of the furnace when we burn corn. We also have a great local farmer that is Johnny on the spot to deliver us fuel. The down side of corn is that it doesn't combust as cleanly and we get major clinker buildup in the burn pot that must be cleaned out regularly or the air channels plug up and combustion and heat output suffer.

Wood pellets, on the other hand, are usually a little more expensive than corn, and do not produce as much heat per ton, therefore reducing the total heat output of the furnace. They also are more prone to poor handling, leading to disintegrating pellets and combustion problems. The up side of wood pellets is that they don't produce clinkers, though they can produce a fair amount of ash if the quality is poor or the moisture level is high. Pellets are likely to be around in good supply through many heating dealers, based on the proliferation of residential systems.

Our current practice is to blend the fuels, 2/3 corn, 1/3 pellets. With our small scale of using 6-8 tons annually and filling the bin by hand each night, this isn't much additional work for us, and the burn performance is great. We find that we get the higher output of the corn (albeit less than pure corn), with the lower clinker and combustion complications of the wood pellets.

We found, as predicted by others, that better fuel equals better performance in the furnace. Our first year we were plagued by chimney problems. After working those out, we found we also had purchased a bad batch of pellets with an inordinate level of fines which were plugging up the augers, causing stacking in the hopper, and leading to poor burn performance. Now we pay more attention to high quality pellets and corn and are much more satisfied.

**Considerations & Configuration, and how the unit works for us:**

Biomass (our version of it) can be tricky to manage during oscillating warm and cold weather, like a variably cloudy-sunny day in mid-later spring. We've found it better to shut down the LDJ for the day and use the propane in the event we need it. Otherwise we have lots of weird combustion, smoke, and sometime exhaust in the greenhouse.

We find that we need to clean the unit out in the burn chamber every 24 hours, or else the ash and/or clinkers build up to a point where they begin to interfere with combustion and operation.

Roof penetration for the chimney is a problem through an inflated poly roof. We have tinkered with and improved it, but still have dripping during heavy rains. It is probably worth it to put a rigid polycarbonate panel over a bigger section of the frame and route the chimney through that. LDJ now makes a power vented unit; this would likely be a better option, though one would need to be careful about how the exhaust would mesh with the intake louvers on a mechanical vent system.

**Key Points:**

- Biomass may be cheaper in the long run if you burn a lot of fuel because you have a long heating season, a lot of volume, or aim for high temperatures. Obviously, fuel prices matter.
- Biomass is likely to require a lot more hands-on work of the tinkering or fussing variety, unless you have a very automated (i.e. expensive) unit.
- Good quality fuel will result in better performance.
- Biomass systems will occupy more space than petroleum heaters; in our case we have given up interior greenhouse space for the LDJ, feed hopper, and fuel storage.
- Be prepared to tinker with the biomass unit and greenhouse HVAC to make it work.

## New Copper Fungicides for Organic Disease Management in Vegetables

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There are several different copper fungicides approved for use in organically produced crops. Copper fungicides are important tools for managing diseases that cannot be effectively managed with cultural practices alone. They have broad-spectrum activity, acting on bacteria as well as fungi. Following many years of use, there is a lot more information on efficacy of copper fungicides than the newer biological products. Manufacturers of some biologicals recommend that they be used in a management program with copper fungicides (often in alternation or at low label rate). Thus it appears copper fungicides will continue to be important for managing diseases. Copper fungicides differ in their active ingredient, use rate, re-entry interval, and the amount of copper. Copper is an inorganic compound thus it does not breakdown like organic compounds and consequently copper can accumulate in soil when used intensively. Plants take up some copper from soil because it is a micronutrient. Similarly, humans need a small amount of copper in their diets. Metallic copper equivalent (MCE) is a commonly used measure of the quantity of copper in fungicides.

Three copper fungicides registered recently are Badge, Cueva, and Nordox. They differ in active ingredient, labeled rate, MCE, and REI (see table). All three are OMRI-listed.

Four experiments were conducted in 2013 at LIHREC on Long Island to evaluate Badge X2 (0.75-1.75 lb/A), Cueva (2 qt/A), and Nordox 75WG (1 lb/A). They were compared with a standard copper fungicide, Basic Copper 53 (2-4 lb/A). The rate used was the maximum-labeled rate for the crop (see table) or the rate recommended by the manufacturer. The goals of the experiments were to determine whether there were differences among these products in ease of mixing, amount of visible residue on plants, crop safety, and efficacy. Amount of residue was assessed by applying these four fungicides at least three times on a weekly interval to plots of tomato, lettuce (Romaine and butterhead), and Brussels sprouts in three adjacent replicated experiments. The later two crop types were also examined for injury from the treatment. Efficacy was examined for powdery mildew in zucchini. Three additional copper fungicides were included in the efficacy experiment: Champ (1.33 pt/A), NuCop (2.66 pt/A), and a conventional (non-organic) copper fungicide, Cuprofix Ultra 40 (2 lb/A). A preventive 7-day application schedule was used starting 4 weeks after transplanting. A total of five applications were made. Powdery mildew was assessed weekly by estimating severity on upper and lower leaf surfaces. Applications in all experiments were made with a backpack sprayer that delivered 50 gal/A at 54 psi.

Clear plastic bottles were used to prepare the fungicide solutions for application which facilitated observations on mixing ability. The bottles were filled with the quantity of water needed, next the product was added, then the container was shaken before spraying. Cueva was observed to mix most readily into water, none of the product settled to the bottom of the container. In contrast, vigorous shaking was required with Basic Copper 53 to get product that settled into solution. NuCop was similar, but it was not as difficult to loosen settled material. After spraying, there was no residue of Cueva visible on the inside of the bottle. More time was needed for clean up with Basic Copper 53 and Nordox 75WG because both left residue on the inside of the bottle.

The copper fungicides tested also differed in amount of visible residue on plants and occurrence of injury to treated plants (crop safety). The most residue was observed on leaves of all crop types (tomato, lettuce and Brussels sprouts) and on tomato fruit on plants treated with Basic Copper 53. Less residue was observed on plants treated with Nordox (red color) or Badge; neither was consistently better across all crops. Cueva left the least amount of residue. Nordox caused the most injury to lettuce and Brussels sprouts; Basic Copper 53 caused slightly less injury; Badge caused much less injury; while Cueva caused very little damage. All products affected the Butterhead lettuce variety much more severely than the Romaine.

There was some variation among the copper fungicides tested in efficacy for controlling powdery mildew in zucchini. All were effective based on Area Under Disease Progress Curve (AUDPC) for severity on upper leaf surfaces, which is a summation of severity over all assessments. There were no significant differences among the treatments in AUDPC values or in severity on each rating date; however, the most powdery mildew was observed on plants treated with Cueva. While severity was not significantly greater than with the other fungicides on any individual assessment date, plants treated with Cueva were the only ones that were not significantly less severely affected by powdery mildew than the non-treated plants at all assessments. Degree of control achieved based on AUDPC for severity on upper leaf surfaces was 40% for Cueva, 41% for Badge, 62% for Cuprofix Ultra, 65% for Nordox, and 66% for Basic Copper 53, NuCop, and Champ.

*Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Before purchase, make sure product is registered in your state and approved by your certifier. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.*

## Emerging New Pests (Organic Session)

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In this session I will introduce the new edition of the Resource Guide to Organic Insect and Disease Management, and present information about some of the up and coming pests and diseases. The second edition of the Resource Guide to Organic Insect and Disease Management was published earlier this year. It is available for purchase, or as a free pdf, at http://web.pppmb.cals.cornell.edu/resourceguide/ . The new edition has chapters on four additional crop families and four additional pest and disease management materials. The biology of the disease organisms and pests is presented for each crop family, and cultural management practices are recommended. Materials are recommended for rescue treatment. A unique feature of this publication is the presentation of efficacy data for each of the 17 organic pest and disease management materials. In addition to the efficacy data, these chapters include a description of the material, how it is made, how it works, OMRI listed brands, safety and environmental effects and much more. The second edition was needed not only to include more crop families and pest management materials, but also to update the older chapters with new and/or mounting pests and diseases. The following are a few of the serious new concerns for growers in New England.

### STEM AND BULB NEMATODE (*Ditylenchus dipsaci*)

The stem and bulb nematode, also called the garlic bloat nematode, is becoming an important garlic pest in the Northeast. Although first reported in the 1930s, it first appeared as a major pest in New York in 2010. Now it is found throughout the Northeast. The most common means of spread is by infested garlic seed. The microscopic worms feed by piercing root and leaf cells with their stylet. Leaves of severely infected plants turn yellow and dry prematurely. Plants may be stunted. The roots are usually at least partially missing, and the basal plate may appear to have a dry rot similar to Fusarium basal plate rot.

The pest is favored by wet, cool conditions. Although the pest is not active in hot, dry weather, such weather may exacerbate symptoms. The nematode survives freezing and/or hot weather in soil and plant debris.

Cultural Control

1. The most important way to avoid garlic bulb nematode is to use uninfested garlic for seed.
2. Monitor for symptoms of infestation during the growing season and submit suspect plants to a diagnostic lab for confirmation. Contact the lab to get instructions regarding how to take and where to send the sample.
3. DO NOT use garlic that is known to be infested for seed. Even bulbs that show no symptoms may have low levels of infestation. Do not sell any garlic for seed from a

potentially infested lot. Do not replant garlic in an infested field for at least four years. Other hosts include all Alliums, celery, parsley, and salsify.

4. Mustards, sorghum-sudan grass, and other bio-fumigant cover crops have been shown to reduce nematode populations. These nematodes can survive in dry debris, making sanitation of equipment and storage areas important.

Materials Approved for Organic Production

None.

**SLIPPERY SKIN and SOUR SKIN of onion** *(Pseudomonas gladioli and Burkholderia cepacia)*

With both slippery skin and sour skin the bulb of the onion becomes soft and watery. Both of these diseases have been common the past few years due to the long periods of wet weather. In slippery skin the central part of the bulb rots and pops out when the bulb is squeezed. Similar to slippery skin, squeezing an onion bulb infected with sour skin will cause the central portion to pop out, but with sour skin the central portion is not the rotten part. It will be firm and usable. Sour skin causes some of the other scales of the bulb to become translucent and viscous. Scales adjacent to rotting ones on either side may be fine. The disease gets its name from the pungent sour odor of infected bulbs.

The slippery skin pathogen is primarily a wound pathogen. Care during cultivation and harvesting is very important, especially in wet years. Sour skin a sporadic problem, and is more common when there is a lot of water from rain or excessive irrigation on the surface of the soil. The pathogen is soil-borne and transferred by accumulation of water at the neck of the onion. The bacteria move down the leaf through the neck to the corresponding bulb scale. High temperature after wet periods favor the disease.

Cultural Control

1. Avoid excessive overhead irrigation, especially late in the season. Drip irrigation may avoid the problem if there are not heavy rains.
2. Minimize wounding of leaves during fieldwork and harvest.
3. Harvest only when onions are fully mature and weather is dry.
4. There is some varietal tolerance to sour skin. The varieties Redwing, White Cloud, and Bello Blanco ranked first, second, and third, respectively, for tolerance in a trial conducted in Washington State.
5. Dry onions well before putting into storage.

Materials Approved for Organic Production

None.

**SWEDE MIDGE** (*Contarinia nasturtii*)
The swede midge is a serious insect pest of cruciferous plants, such as cabbage, cauliflower, and broccoli because the larvae feed on and disfigure or destroy the growing tips of the plant. The first discovery of swede midge in the US was in 2004 in western NY. The insect is native to Europe and southwestern Asia and has been known in North America only since 2000, when it was identified in Ontario, Canada. Swede midge has the potential to spread to most crucifers growing areas in the US and Canada. A Cornell website has been developed that describes its biology, the damage it causes, and management strategies. See http://web.entomology.cornell.edu/shelton/swede-midge/
Eggs are laid on multiple growing tips of plants. Plant damage is caused by the larvae, which are small maggots. Larvae produce a secretion that breaks down the plant cell wall, allowing them to feed on the liquid contents. Larval feeding changes the physiology of the plant and results in the formation of swollen, distorted, and twisted tissue.

The swede midge spends the winter as pupae in the soil. Adult flies emerge from overwintered pupae from May through June. Mating occurs soon after emergence, and the females lay eggs in the newest growing points of the plant. Subsequent overlapping generations are produced during the summer months, ensuring problems with this pest over the entire growing season.

Swede midge injury is often difficult to distinguish from other factors that can damage the growing tip of a plant, such as mechanical injury from cultivation, other insect or animal feeding, molybdenum deficiency, herbicide injury, genetic variation of the plant, and heat or cold stress. For confirmation of injury due to swede midge, look for the larvae, which can be found on or within the plant by putting suspected damaged plant tissue in black plastic bags and leaving them in the sun for an hour or less. The light colored larvae will leave the plant tissue and be visible on the black plastic.

Cultural Control:
1. Use clean transplants.
2. Implement a two- to three- year rotation to non-crucifer crops. Control cruciferous weed hosts during the rotation period. Adults are weak flyers, but may be carried by wind to new fields, so rotate as far from an infested field as possible.
3. Destroy crop as soon after harvest as possible.

Materials Approved for Organic Production

None have been shown to be effective.

**Nutrient Management in Organic Cropping Systems**

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Soil fertility amendments used in organic cropping systems are typically complex, whole nutrient source materials (e.g., compost, animal manure) making balanced nutrient management challenging. Nitrogen is typically the most limiting nutrient in organic cropping systems, but when compost or animal manures are applied at rates high enough to meet crop nitrogen needs, phosphorus (and often other nutrients) is generally over applied. Repeated nitrogen-based application of animal manure or compost results in excessive soil phosphors levels which can lead to crop nutritional problems and threaten surface water quality. For this reason, sole reliance on compost or animal manures to meet crop nitrogen needs should be avoided.

Sustainable soil fertility management on organic farms requires routine soil testing and diligent monitoring of nutrient inputs. Monitoring nutrient inputs and soil test levels over time enables growers to adapt their nutrient management strategies to optimize crop yield and quality and minimize environmental impact. The goal should be to maintain soil nutrients within the *optimum* soil test range. Therefore, when soil test phosphorus levels are above optimum the application of compost or animal manures should be limited to rates no greater than that required to replace phosphorus removal by the crop. Where soil test phosphorus levels are excessive due to previous over application of organic amendments, no phosphorus should be applied.

In order to avoid building soil phosphorus levels to above optimum or excessive levels, organic growers need to develop creative nutrient management strategies to meet crop nitrogen needs. Growers can reduce the need for organic amendments by including legumes (either perennial forage or winter annuals) in the rotation. For example, if hairy vetch is planted early enough in the fall and allowed to grow late enough into the spring it can satisfy a large portion of the nitrogen needs of even the most demanding vegetable crops. Then, only a small amount of nitrogen will need to be provided by an organic amendment allowing a grower to apply it a rate low enough that phosphorus is not over applied.

It is also important to recognize that soil organic matter can be a significant source of available nitrogen. Where organic amendments have been applied for several years and soil organic matter levels have been increased, lower rates of organic amendments are often required to satisfy crop nitrogen needs. One way growers can determine a soil's capacity to supply nitrogen is to withhold pre-plant amendments from a small portion of the field and observe the relative crop growth and vigor compared adjacent areas that received pre-plant amendments.

Growers may also consider alternative organic amendments with higher nitrogen to phosphorus ratios than compost and animal manures. These include materials such as feathermeal and bloodmeal as well as pelletized blended organic fertilizers containing these materials. An added benefit of these materials is that they are easier to handle and tend to release nitrogen much more rapidly than manure and compost making them useful as sidedress amendments. Postponing the application of these nitrogen sources until sidedress time gives growers the opportunity to use in-season observation and soil testing (e.g., the pre-sidedress soil nitrate test, PSNT) to determine if and how much additional nitrogen might be needed.

Sustainable nutrient management is a critical component of organic cropping systems. Good record keeping and routine soil testing will enable growers to adapt their nutrient management strategies to meet crop nutrient needs and minimize environmental impact. Growers must use an integrated nutrient management strategy for organic systems that maximizes nitrogen inputs from legumes and supplements legume nitrogen with animal-based products at rates close to phosphorus removal rates by the crop.

**Contrasting Soil Management in High Tunnels Versus Field Production**

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High tunnel crops and soils are often more intensively managed than field crops. Intensified production may increase soil nutrient removal, tillage and traffic. The effect that this may have on soil quality is uncertain. However, a decline of soil quality has not been confirmed by research. University research and extension studies have mainly focused on crop production methods. Also, most research in high tunnels in the US is still fairly recent. This question of soil quality sustainability becomes more important as existing tunnels age and growers ponder whether to maintain structures in their current location or construct new high tunnels at different locations, and as growers plan to use high tunnels on a larger scale where frequent structure shifting is less feasible.

It is the objective of this research study to determine if the presence of a high tunnel affects soil quality in a silt loam soil after eight years. Because of the design and management of the experiment plots, we were also able to investigate the influence of soil management (i.e. conventional vs. organic management) on soil quality.

High tunnels were established at the Kansas State University Horticulture Research and Extension Center at Olathe, Kansas, in 2002, on a Kennebec silt loam soil that was formerly pasture. Six high tunnels and six field plots have largely been managed with matching crops. Three of the high tunnels and field plots have been managed with organic amendments and three with conventional amendments.

To determine if high tunnels alter soil quality, a comparison was made of soil from high tunnels and adjacent fields. Soil samples representing a high tunnel or field were a combination of five random soil probe collections to the 15-cm depth within crop rows. Chemical indicators of soil quality include pH and salinization. Exclusion of leaching rainfall makes high tunnels susceptible to salinization, so it is advisable to monitor high tunnel salinity.

Because organic matter influences soil structure, nutrient storage, water holding capacity, biological activity, tilth, water and air infiltration, erosion, and even efficacy of chemical amendments made to soil it is commonly used as a biological indicator of soil quality. Soil organic carbon is used to estimate organic matter and in non-calcareous soils organic carbon is equivalent to total carbon

Particulate organic matter (POM) as an indicator of soil quality has the advantage of a faster response to environmental change than soil organic matter as a whole. Particulate organic matter is the labile organic matter of size fraction 53 microm – 2 mm. Particulate organic matter in other research has been correlated to microbial biomass, C and N mineralization, and soil aggregate formation and stability.

Results from our study show that soil salinity was not affected by management (organic vs. conventional) but was higher in the high tunnel plots in 2005. These levels went down between 2005 and 2010 due to a change in watering practices from only using drip tape to using a combination of drip tape and over-head watering. There was also one winter season where the plastic was removed and rainfall was allowed to leach the soil.

Total carbon didn't change significantly between 2005 and 2010, and there was only a slight effect of high tunnel vs. field. However, the organically managed plots in both growing systems had significantly more soil carbon than the conventional treatments. Soil fertility amendments consisted of only mineral fertilizers in the conventional (pre-plant and fertigation) while the organic treatments received annual additions of compost.

The particulate organic matter (POM) carbon levels went up between the two sampling periods in all plots, but this was only statistically significant in the organically managed plots. Like the total soil carbon, levels were significantly higher in the organically managed plots as compared to conventional, and for this fraction of the carbon pool, the high tunnel plots had higher levels than their comparison field plots within the organic system. In 2010, the ratio of the POM to total soil carbon was highest the high tunnel organic plots, second highest in the organic field plots, lower in the conventional high tunnels and lowest in the conventional field plots. The lower levels in the field as compared to the high tunnel may be due to protection from weathering and leaching, even though temperatures are often higher in high tunnels, that could lead to more rapid oxidation of organic matter.

In summary, this replicated field study shows that organic matter levels and particulate organic matter levels continue to go up in high tunnels managed for vegetable production after eight years, especially under organic management. Salinity should be monitored and managed as needed with irrigation and/or occasional exposure to rainfall.

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## Growing My Own Organic Nitrogen

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My wife, Liz, and I have been farming in Norwich, Vermont since 1979. We farm approximately seventy acres, mostly alluvial soils ranging from light sandy soils to heavier silt loam. In any given year usually no more than half of those acres are occupied by vegetable crops, the rest being in cover crop and green manure rotations, straw, and fallow or buffer areas. For over twenty years most of our crops have been certified organic; the exceptions being our sweet corn and greenhouse bedding plants.

As on any vegetable farm, good soil fertility has been a major concern, and regular soil testing has been an important routine on the farm. I have relied heavily, especially since being certified organic, on locally purchased dairy manure as well as various amendments such as sulfate of potash magnesia, lime, and trace minerals. I have also used raw hen manure from time to time.

With the introduction of stricter standards for using raw manures and compost I have in the last several years found it increasing difficult to include raw manures in our fertility program. This has resulted in more extensive use of bulk composted hen manure from a large poultry farm. It contains a wide range of nutrients and is especially rich in nitrogen, phosphorus and calcium. I also produce large quantities of compost using the composted hen manure mixed with various carbon-rich materials such as leaves and purchased waste silage and haylage. Both the straight composted hen manure and our own compost have proven very useful for successfully growing a wide variety of vegetable and soil building crops.

However, there has been a down side to using these materials: over the last several years soil tests have indicated an excessive accumulation of some nutrients, especially phosphorus, and a steep rise in pH readings. Many of our fields now have a pH of over 7. The obvious solution would seem to be to cut down on the amount of composts applied to our fields. However, when I have attempted cutting back on compost, lack of nitrogen has become a limiting factor. Past use of appropriate amounts of Chilean nitrate has helped alleviate this problem, but with the likely ban of this fertilizer the need for adequate nitrogen has become critical. There are many fertilizer materials available for organic production, but with the exception of Chilean nitrate most of them also contain the same nutrients that have become excessive in our soils and are therefore not appropriate.

Two years ago I concluded that a possible solution for our farm was to try and grow our own nitrogen. Although I have often grown leguminous green manure crops in our rotation, I have never seriously considered growing a cash crop relying solely on a prior green manure crop for its entire nitrogen requirement. We are fortunate in having enough available land to implement longer rotations including leguminous green manure crops so I began to experiment with several different combinations of green manure crops followed by cash crops.

My first step was to review my most current soil test results to determine which fields had especially high non-nitrogen fertility levels and would therefore be suitable for these trials. I then chose a few different crop combinations which I thought might achieve the goal of growing enough nitrogen for the following cash crop. I have relied primarily on a winter rye/hairy vetch mix, a field pea/oat mix, and a field pea/winter rye mix. All the legumes were inoculated with their appropriate inoculant. Cash crops were later season crops such as late potatoes, cole crops and fall greens, planted or transplanted after near maturity of the green manure crop.

Winter Rye/Hairy Vetch : Seeded rye at approx. 100# and vetch at 30#/A in early to mid-September after summer cash crop or fallow; allowed to grow in spring until rye was in full flower; mowed with flail mower; plowed; rotovated or harrowed; and planted cash crop when residue was sufficiently broken down. In the fields where this was tried, the mix, when allowed to grow nearly to maturity, produced a lush and thick mass of green matter which subsequently broke down fairly rapidly. Weeds were nearly completely suppressed and there were extensive nodules on the vetch roots. In all fields subsequent plantings of heavy feeding crops such as potatoes, broccoli and fall spinach showed no signs of nitrogen deficiency whatsoever. No additional fertilizer was used.

Rye/Vetch, two cycles: A variation on the above is to let the mix grow completely to maturity before flail mowing twice. The huge mass of rye and vetch seed germinates under the thick residue cover even without additional incorporation, and will grow through late summer into fall. The result is a dense mass of old residue and new growth. The soil underneath is always moist and open and I have noticed abundant earthworm activity. The field is plowed in early November. Crops grown the following spring did receive some early supplemental nitrogen (20-30#N from Chilean nitrate, but later growth was vigorous and showed no N or other nutrient deficiency. In the future I plan to try waiting until spring to incorporate the overwinter rye/vetch. I did discover, however, that the residual vetch seed remains viable for at least two years and can become a very troublesome weed. I have solved this problem by using this sequence only on fields where large transplanted crops are grown or on non-organic sweet corn where an herbicide is an option.

Field Peas/ Oats: Seeded as early as possible in the spring, this mixture, when allowed to grow to full pea flowering stage has provided enough nitrogen to support subsequent heavy feeding crops. Seeding rates were approx. 60# of oats and up to 100# of peas. Seeds were sown separately with a spin spreader because the heavier peas tend to spread much wider than the oats.

The mix was flail mowed soon after the first pea flowers formed small pods and then rototilled to incorporate. (In one planting I made the mistake of letting the peas form full sized but seemingly immature peas. The result was that the following crop was loaded with pea plants as a weed!) The incorporated crop was heavy and lush and was broken down enough in under two weeks to direct seed a mid summer crop of leafy greens. The greens were fast growing and of good quality with no indication of any N deficiency. A subsequent fall planted rye seeding was also vigorous and showed no lack of N.

<u>Field Peas and Rye:</u> Winter rye is seeded in mid September, but thinly, leaving 6" to 8"between plants. Early in the spring I over seeded approx. 100# of field peas onto the rye seeding. I was able to incorporate the peas by running a rotovator over the field at a speed just barely slower than the ground speed of the rotating tines. Some of the rye pants were disturbed and killed, but most recovered and the peas were adequately covered. The mix then grew much like the Pea/Oat mix. The great advantage was that there was a standing, over-winter crop of rye to protect the soil from winter and spring erosion.

<u>In Conclusion:</u> I have been very encouraged by the results of these experimental green manure plantings and certainly plan to continue with these and other mixes. My goal was to try and grow, using various legume mixes, enough nitrogen to support healthy vegetable plant growth without adding any of the nutrients which have become excessive in some of our fields. For us it was a risky undertaking as it was not clear that the goals could be met. Not being able to harvest an adequate crop has always been a possibility and it has been very gratifying that for the most part subsequent crops have been of high quality and not lacking in nutrients including, especially, nitrogen. A significant added benefit has been that there has been a huge saving in the costs incurred in buying, hauling, composting, spreading and incorporating manures, composts and other fertilizing material. There are many aspects of these practices which I really need to better define. For instance: I need to more carefully record seeding rates and seeding times; I need to better organize before and after soil tests (several "after" have been sent in an will be available in time for the conference); and I need to more accurately monitor crop yields and biomass measurements. All in all, however, I am satisfied that I am headed in the right direction and doing something which will benefit our farm and hopefully other farms. Most importantly, perhaps, is that experimenting with these crops is interesting, rewarding and fun!

## Carrots for winter sales: varieties, planting dates and post-harvest care

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With funding provided by the Northeast SARE program, the UMass Extension Vegetable Program has been studying ways to increase the sale and harvest of vegetable crops during the winter months (defined here as November through April). In response to increasing demand for local vegetables through the winter months, growers are expanding their production of root vegetables for winter storage. Carrot is a widely grown storage crop that suffers from declining quality in sub-optimum storage conditions. Growers in New England are experimenting with new varieties and using a wide range of harvest and post-harvest practices for carrots to meet winter market demands. Published studies suggest that changing simple factors such as washing, variety, and maturity at harvest may affect the prospects for long-term storage. We used carrots as a model crop to study varieties, handling and storage options for long-term storage, over the 2010-11 and 2011-12 seasons. Below are some findings from our study of nine different varieties of storage carrots.

**Methods:** During the 2010-2011 seasons, we selected six storage carrot varieties (Bastia, Berlanda, Bolero, Canada, Carson, Sugarsnax) with varying maturity dates. Carrots (untreated, not pelleted) were seeded on June 28, using a Clean Seeder, in double rows 18 inches apart, hand weeded, and thinned to 1 inch on July 28 . Trickle irrigation was surface-applied along each row as needed. Carrots were harvested on four dates; September 29, October 12, October 27 and November 10. At harvest, carrots were sorted into marketable and unmarketable, based on the USDA United States Standards for Grades of Topped Carrots U.S. No.1 and U.S. No.2. Unmarketable carrots included those that were too small, had insect damage, had splits or forking, were misshapen, or had excessive root growth. We measured marketable wholesale and direct market weights, and counted all marketable carrots and culls. We evaluated flavor by measuring sugar content using the Brix test. At harvest all carrots were washed by hand in buckets and placed into storage at 32 degrees F and RH>95% in perforated plastic bags immediately after harvest. From December through March, we continued to sample Brix values and water loss of stored carrots.

**Results:** Weight of marketable carrots appeared to increase across harvest dates for most varieties, indicating that carrots continued to grow late into the season without compromising quality from insects, disease, or other factors. Quality of Berlanda and Bastia, however, may have started to decline at the end of the harvest period. Brix score (sweetness) varied across harvest dates, and the date of highest sugar content varied with variety. See the variety descriptions below for more information on marketable weights and brix scores at harvest. In 2010-11 trials, Bastia had the highest number of marketable carrots, followed by Bolero and Carson. Sugarsnax had the highest number of culls, particularly forked and misshapen carrots.

In storage, Brix score (sweetness) appeared to increase for the first several months and then decline rapidly after the fourth month of storage. Water loss continued at low levels throughout the storage period, and averaged 5-11% loss between harvest and March 1. See *From Field to Storage; High Quality Carrots* by Ruth Hazzard for more details on the effect of long term storage on overall carrot quality.

The following numbers are the average for all harvest dates. Marketable is for USDA wholesale standards.

BERLANDA (85 days) Dark orange, cylindrical, 9" Berlikum with good tops. Source: Bejo. At harvest; Brix score: 7.2. Marketable weight: 50%

BOLERO (75 days) Medium-long, 7-8" roots are uniform, thick, slightly tapered, and blunt, with a medium core and average internal color. This Nantes has good taste fresh, and after long-term storage. Resistant to Alternaria and Cercospora blight. Heavy, tall tops. Source: Johnny's. At harvest; Brix score: 7.89. Marketable weight: 42%

CARSON (90 days) Early Chantenay, 7 1/2" deep orange, conical roots, with broad shoulder, blunt tip, and strong, tall tops. Source: Bejo. At harvest; Brix score: 8.03. Marketable weight: 53%

BASTIA (85 days) Smooth jumbo Flakee with deep orange color, 9" roots. Strong tops, stores well. Source: Bejo. At harvest; Brix score: 7.27. Marketable weight: 54%

CANADA (95 days) Dark orange, conical, 9" Chantenay with broad shoulder, strong tops, and long blunt tip. Source: Bejo. At harvest; Brix score: 7.62. Marketable weight: 53%

SUGARSNAX (68 days) Smooth, deep orange Imperator has 9" tapered roots with strong, medium-tall tops resistant to Alternaria, Cercospora, and Pythium diseases. Tender and sweet. Source: Johnny's. At harvest; Brix score: 7.65. Marketable weight: 28%

**Methods:** During the 2011-12 season, we observed six carrot varieties (Berlanda, Brest, Bolero, Carson, Deep Purple, Florida). Carrots were seeded July 26 and harvested on three dates November 3, November 14 and November 28. We measured wholesale and direct sale marketable weights, counted culls, and measured dimensions of carrots (length, width, pith width). Those that were in good condition but too small or moderately misshapen were included in direct sale marketable weights. We measured Brix score at the time of harvest, and again after 6 months of storage. For three of the varieties (Berlanda, Bolero, Brest), we stored half of the carrots washed and half unwashed. We then evaluated staining, presence of rot, and top sprouting, after 6 months of storage. See *From Field to Storage; High Quality Carrots* by Ruth Hazzard for more details on the effects of washing verses not washing on carrots during long term storage.

**Results:** At harvest Brix score was higher for the two later harvests (November 14 and November 28) compared to the first. Marketable weights were also higher for the later harvests. In general marketable weights were lower than in 2010, likely the result of a later seeding date and cool wet fall. In 2011-12 trials, Berlanda was the highest yielding variety, both in terms of numbers and weight of wholesale marketable carrots. Brest, Bolero, and Florida were also high producers. Carson and Deep Purple did not fare as well, with Deep Purple producing less than one third the marketable weight of Berlanda. These low yielding varieties produced approximately an equal weight in direct sale marketable carrots. Higher yielding varieties produced additional direct-sale carrots equal to about 2/3 of wholesale weights, and were still by far the best producers even for direct sales. The numbers below are the average of three harvest dates, using the more lenient criteria for marketability in direct markets.

BERLANDA (85 days) Dark orange, cylindrical, 9" Berlikum with good tops. Source: Bejo. At harvest marketable weight: 48%

BOLERO (75 days) Medium-long, 7-8" roots are uniform, thick, slightly tapered, and blunt, with a medium core and average internal color. This Nantes has good taste fresh, and after long-term storage. Resistant to Alternaria and Cercospora blight. Heavy, tall tops. Source: Johnny's. At Harvest marketable weight: 47%

CARSON (90 days) Early Chantenay, 7 1/2" deep orange, conical roots, with broad shoulder, blunt tip, and strong, tall tops. Source: Bejo. At harvest; Marketable weight: 25%

BREST (90 days) Dark orange, full season slicer, with cylindrical to slight taper. 9" roots carry weight to the tips. Excellent tops for mechanical harvest. Source: Bejo. At harvest Marketable weight: 42%

DEEP PURPLE (80 days) Dark purple, 7-8" tapered roots with sweet flavor, similar to Purple Haze. Tall, strong, healthy tops. Color fades when cooked. Source: Bejo. At harvest marketable weight: 25%

FLORIDA (95 days) Cylindrical, orange 9" roots are sweet, with good tops for mechanical harvest. Very productive. Source: Seedway. At harvest marketable weight: 46%

# Garlic Post-Harvest Trial Results

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Post-harvest handling is a yearly challenge for growers in the Northeast. Often the success of the crop continues to be dependent on the weather even after it is out of the ground, with drying going well in dry years and poorly in rainy years. We set the goal of determining the optimal handling to dry garlic through three on-farm post-harvest trials in 2012 and three more in 2013. Through these trials we were able to determine that garlic can tolerate more light, heat, and pruning during the drying process than was previously demonstrated, and that we can create a more effective drying environment regardless of the weather using high tunnels.

**Choosing post-harvest treatments**

Treatments were chosen based on what growers throughout New York indicated worked well for them and through the advice of the Garlic Seed Foundation. The following options were chosen: drying occurred either in a high tunnel with shade cloth or in an open air structure such as a shed or barn; Roots were either left on the bulb until drying was completed or cut off immediately (leaving the basal plate intact); tops were either left on until drying was completed or cut off at various heights during or directly after harvest, and garlic was washed immediately after harvest or was left unwashed. These treatments were combined in every possible way on each of the three farms.

**Effects of treatments on bulb quality, disease incidence, drying time, and final weight**

<u>High Tunnel vs. Open Air:</u> Across the trials garlic in high tunnels dried an average of three days faster than garlic in open air structures. Garlic dried in high tunnels had slightly better wrapper quality (tighter, less discoloration) than garlic dried in open-air structures at one site during both years. Garlic dried in tunnels also had slightly lower disease incidence (*Aspergillus, Embellisia* and *Botrytis)*, though disease was not severe in any site or treatment in either year. No garlic treatments showed damage from being dried in the high tunnel.

The environment in the high tunnel needs to be carefully managed in order to be most effective. Technically temperatures can reach 121° F before waxy breakdown, the physiological disorder resulting from high temperatures, is initiated. However, to account for uneven heating in the high tunnel and possible delays in dropping temperatures through ventilation, the grower cooperators agreed that 110° F was a safer limit. Thermometers to monitor the temperature were located at the same height as the garlic.

Limiting temperature is just one aspect management. Maintaining air movement in the high tunnel through the use of internal fans helps even out the temperature and humidity, particularly if drying racks are stacked. The grower cooperators also agreed running dehumidifiers at night and whenever the high tunnel was closed was beneficial, as it removed up to 20 gallons of water from the air during an eight-hour period and kept conditions closer to optimal. Without closing the tunnel and running dehumidifiers the humidity in the tunnel can reach up 100%, which pauses or reverses the drying process.

Roots trimmed vs. roots untrimmed: No statistically significant differences were observed between these treatments in regards to bulb quality, weight, or disease incidence in either year. Root pruning is considerably more difficult and time consuming on wet roots than dry roots.

Tops trimmed vs. tops untrimmed: Trimming the tops mechanically in the field using a sickle-bar mower greatly increased the speed of harvest and reduced the space needed for drying. Top trimming did not have a significant effect on disease incidence in dried bulbs, but there were differences in bulb weight at two of the farms in year one, with un-cut bulbs being slightly heavier (Table 1). It was unclear if this difference was due to weight loss or to double bulbs, since the number of bulbs is greater in the treatments with lower weights. Because of this question, relatively uniformly sized, non-doubled bulbs were chosen for the samples during year two instead of taking every bulb from a plot, including doubles, as had been done in year one. In addition to this change, additional cutting lengths were also added to determine if leaving some stem would affect weight or disease incidence. During year two, the pruning length did not affect the dried weight of bulbs significantly (Table 2). Furthermore, there were no significant differences in disease incidence across any of the trimming treatments.

Table 1: Treatments and average weights aggregated from three trial sites, each with three replications per treatment.

| Treatment | Average weight/head | Count |
|---|---|---|
| Cut at 6” | 0.113lbs | 1036 |
| Uncut | 0.130lbs | 972 |

Table 2: Treatments, aggregated weights of treatments across replications, counts, and average weights per head from year two. Data were combined from all three sites.

| Treatment | Weight/ treatment | Count | Average weight/head |
|---|---|---|---|
| 1.5 inch | 23.7lbs | 183 | 0.129lbs |
| 6 inch | 22.7lbs | 186 | 0.122lbs |
| 10 inch | 24.4lbs | 206 | 0.118lbs |
| Uncut | 39.4lbs | 302 | 0.130lbs |

Washed vs. unwashed**:** Washed garlic initially had very clean, tight wrappers, but became more discolored than the unwashed garlic during the drying and curing process. Most discoloration could be removed by removing 1-3 wrapper leaves, but this extra step is time consuming. Disease incidence, particularly *Aspergillus* and *Embellisia,* was slightly higher in washed garlic. This treatment was discontinued after year one of the study because the returns from the process were deemed too low.

**Discussion of results and next steps:** These trials have demonstrated that it is possible to dry garlic quickly and effectively by creating a warm, dry environment. Garlic can be dried at 110° F without damage to the bulbs. Furthermore, one to two layers of shade cloth provides enough protection for bulbs to prevent damage from the sun.

These trials have also demonstrated that trimming the tops of the garlic while it is in the field rather than drying the whole plant intact does not increase disease issues or reduce bulb weight. This finding is particularly useful to growers who find that they have too much garlic for their drying area, as they can remove the tops without concern that the garlic will become unmarketable or lose value as a result.

Notably, all of these trials were conducted in relatively dry years. We might expect that if the season had been wetter, differences between high tunnel and open-air drying systems would have increased rather than decreased. The worse the outside conditions for drying, the more important it becomes to be able to control the environment. High tunnels offer more significant opportunities for control than most barn systems.

Not every grower will be able to use a high tunnel system to dry garlic, or will want to cut the tops. These recommendations do not need to be followed exactly for success, but if a grower is struggling with disease and post-harvest breakdown, applying the principles of limiting humidity and increasing temperature while drying should prove beneficial, whether accomplished in a high tunnel, a hay mow, etc.

To follow-up on these studies, we would like to address growers' questions about the effects of these treatments on longer-term storage and on quality factors such as sulfur compound concentration, and would like to determine what the best environment is to store garlic for one, three, or 6 months.

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**Overwintering onions for early spring market**

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***Background & Objectives:*** Growers in the region have been experimenting with planting onion seedlings in the fall, covering them with low tunnels during the winter, and harvesting in the early spring. Some have reported good success, with an early harvest of beautiful bulbed onions, and others have reported challenges including poor survival and early bolting. In 2011-12, we planted seven varieties of onions in Durham at the NH Agricultural Experiment Station (zone 5B), to evaluate potential for overwintering and early spring harvest. In 2012-13, we broadened our study to include ten varieties in Durham and two varieties in North Haverhill NH (zone 4B). This study was done in collaboration with University of Massachusetts researchers, as part of NESARE project LNE10-297. This work was also supported by the New Hampshire Agricultural Experiment Station. The full report, with photographs, is available at http://extension.unh.edu/resources/files/Resource003239_Rep4688.pdf.

***Cultural Methods:*** Onions were grown in a randomized complete block design with 4 replicates, 24 plants per rep. Seeds were provided by or purchased from Johnny's Selected Seeds. Seedway Seeds, and Territorial Seeds. Onions were seeded in 98-cell transplant trays and were transplanted outdoors at a spacing of 6" apart in three rows 6" apart on raised beds covered with embossed black plastic mulch. Low tunnels made of 10' PVC bows were installed over the onions in late fall. Plants were covered with heavy-duty rowcover (1.25 oz/yd$^2$) and an additional layer of greenhouse poly (6mil) for the winter. Dates of cover application and removal are shown below. In 2012-13, half of the onions were grown under low tunnels, and half were not covered. In both years, we used two planting dates (A and B).

**Table 1. Important Dates for Onion Trial**

<table>
<tr><th></th><th colspan="2">2011-12</th><th colspan="4">2012-13</th></tr>
<tr><th></th><th colspan="2">Durham</th><th colspan="2">Durham</th><th colspan="2">North Haverhill</th></tr>
<tr><th>Activity</th><th>A</th><th>B</th><th>A</th><th>B</th><th>A</th><th>B</th></tr>
<tr><td>Seeded:</td><td>Aug 18</td><td>Aug 18</td><td>Aug 25</td><td>Sep 15</td><td>Aug 25</td><td>Sep 15</td></tr>
<tr><td>Transplanted:</td><td>Sep 20</td><td>Sep 30</td><td>Sep 20</td><td>Oct 20</td><td>Oct 11</td><td>Oct 21</td></tr>
<tr><td>Added rowcover:</td><td>Oct 18</td><td>Oct 18</td><td rowspan="2">Oct 20</td><td rowspan="2">Oct 20</td><td>Nov 6</td><td>Nov 6</td></tr>
<tr><td>Added plastic:</td><td>Dec 16</td><td>Dec 16</td><td>Nov 6</td><td>Nov 6</td></tr>
<tr><td>Removed plastic:</td><td>Mar 14</td><td>Mar 14</td><td rowspan="2">Apr 15</td><td rowspan="2">Apr 15</td><td>Apr 7</td><td>Apr 7</td></tr>
<tr><td>Removed rowcover:</td><td>Apr 5</td><td>Apr 5</td><td>Apr 9</td><td>Apr 9</td></tr>
<tr><td>Assessed survival:</td><td>Mar 13</td><td>Mar 13</td><td>Apr 30</td><td>Apr 30</td><td>Apr 24</td><td>Apr 24</td></tr>
<tr><td>1st Harvest:</td><td>May 12</td><td>May 12</td><td>May 22</td><td>May 22</td><td>Jun 13</td><td>Jun 13</td></tr>
<tr><td>2nd Harvest:</td><td>May 24</td><td>May 24</td><td>Jun 3</td><td>Jun 3</td><td>Jun 22</td><td>Jun 22</td></tr>
<tr><td>3rd Harvest:</td><td>Jun 6</td><td>Jun 6</td><td>Jun 20</td><td>Jun 20</td><td>Jul 2</td><td>Jul 2</td></tr>
<tr><td>4th Harvest:</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Jul 15</td><td>Jul 15</td></tr>
</table>

***Data Collected:*** In early spring, plant vigor (number of intact leaves) and percentage of overwinter survival were measured. As soon as onions were sufficiently bulbed to be considered harvestable, subsamples of 6 plants were harvested from each plot. Subsequent harvests were made at 2-week intervals. Bolting and bulb size were measured at each harvest.

***Results:***

1. ***Low Tunnel Environment.*** The low tunnel covered with 1.25 oz/yd$^2$ rowcover and 6 mil plastic provided substantial temperature protection compared with outdoor temperatures. While air and soil temperatures fluctuated widely inside as well as outside the low tunnel, the minimum temperatures reached in the low tunnel were much warmer than outdoor temperatures. Notably, the soil temperature inside the soil tunnel never went below freezing.

   In 2012-13, we grew overwintering onions outside the low tunnel (uncovered) as well as inside the low tunnel. While onions survived unprotected in both sites, the survival and spring vigor were much lower without the protection of the low tunnel. For example, in Durham, survival ranged from 30-44 % outside the low tunnel, and 62-88% inside the low tunnel. Unexpectedly, survival of unprotected plants was better in the colder site, N. Haverhill (80-85% outside vs. 93-98% inside the low tunnel). This may have been due to extended snowcover in this site.

2. ***Onion Survival & Vigor.*** In low tunnels, all varieties survived the winter equally well. In 2011-12, survival was over 97% for all varieties. Survival was a bit lower in 2012-13, ranging from 62-88% for all varieties in Durham, and 96-98% in N. Haverhill. We found that vigor was greater for the earlier fall planting than for the later planting, and for onions that had been under low tunnels than for those that had been outside.

3. ***Varieties.*** *Winter White Scallion (*T*)* is a hardy non-bulbing scallion, which was grown because of its hardiness, but was not expected to bulb. It did not produce bulbs, but instead produced long white leek-like shanks that had a slight enlargement on the bottom. It could be creatively marketed as an oversized scallion in the spring, but not as a typical bulbing onion.

   *Walla Walla (*SW*)* is a long-day sweet onion that can be fall-planted in the Pacific Northwest as an overwintering onion. In the first year of our trial, it bolted quickly and did not produce large bulbs, perhaps because it bolted before our days reached the 14-16 hour daylength required to initiate bulbing. In the second year of our trial, Walla Walla produced very nice bulbs and did not show a high percentage of bolting.

   *Top-Keeper (*T*), Hi-Keeper (*T*), T-420 (*JSS*), Keepsake (*T*)* and *Bridger (*JSS*)* are yellow storage varieties that produced high quality bulbs in our production system. These varieties varied in their tendency to bolt and in overall bulb size, but all produced marketable early onions.

   Red onions were included only in the second year of the evaluation, 2012-13. *Red Wing (*JSS*)* and *Red Bull (*JSS*)* are red storage onions, *Red Baron (*T*)* is a red scallion, and *Cabernet* (JSS) is an early summer red onion. Of these, Cabernet was the only one that produced marketable bulbs, but it exhibited a relatively high percentage of bolting (20%).

4. ***Bolting.*** Bolting is triggered by a vernalization period (exposure to prolonged cool temperatures) once the plant has reached 4-6 true leaves. By late April in both years, flower stalks (scapes) were evident on some plants. On bolted plants, scapes were evident in the center of the bulb as a small pithy core. For later harvest dates, bolting rendered bulbs unmarketable because it reduced bulb size and because the majority of the bulb was the large pithy scape.

   The percentage of bolting was higher in the first year (2011-12) than in the second year (2012-13), across all varieties. In both years, the earlier fall planting showed a higher percentage of bolting than the later planting. Varieties differed greatly in their tendency to bolt.

**Table 2. Percentage of bolted plants over two years in two locations.**

| | **Durham** | | **North Haverhill** |
|---|---|---|---|
| **Cultivar** | **2012** | **2013** | **2013** |
| Bridger | 33% | 0% | 0% |
| Cabernet | - | 20% | - |
| Hi Keeper | 69% | - | - |
| Keepsake | 33% | 0% | - |
| Red Baron | - | 1% | - |
| Red Bull | - | 28% | - |
| Red Wing | - | 27% | - |
| T420 | 51% | 1% | - |
| Top Keeper | 50% | 0% | - |
| Walla Walla | 92% | 5% | 0% |
| Winter White | 41% | 1% | - |

5. ***Bulb Size.*** In 2011-12, two varieties did not form large bulbs: Walla Walla and Winter White Scallion. For all other varieties, bulbs began to form in April. Average bulb diameters ranged from 2-2.5" on May 12, from 2.6-3" on May 24, and from 3-3.3" on Jun 6. Weight of trimmed bulbs for these varieties ranged from 4-5.5 oz on May 12, and from 5.5-7.5 oz on May 24.

   In 2012-13, four varieties did not form bulbs >2.25 in: Red Baron, Red Wing, Red Bull and Winter White. The remaining varieties formed large bulbs, with weight of trimmed bulbs ranging from 6.6 to 10 oz by June 20. Average bulb diameters of these larger varieties ranged from 1.7-2" on May 22, from 1.8-2.5" on June 3, and from 2.6-3.1" on June 20. In North Haverhill (zone 4B), both Bridger and Walla Walla bulbed nicely, and large (3" diameter) bulbs were ready for harvest by June 13.

***Conclusions:*** We experienced success overwintering onions in hardiness zones 4B and 5B in low tunnels, which provided a protected environment. With both mid-August and mid-September seeding dates, onions were ready for harvest in late May-early June. Bulbs continued to increase in size until late June. The varieties TopKeeper, Hi-Keeper, Keepsake, Bridger and T420 produced nice bulbs in both years; Walla Walla did well in one out of the two years. Of the red varieties evaluated, Cabernet produced nicer bulbs than the other varieties, but it did show a significant percentage of bolting. Planting later in the fall appears to reduce the chances of spring bolting, but there is a tradeoff - the bulbs are also smaller and slightly later to mature.

## Terror Underground:
## Why Wireworms are so Hard to Control

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**Wireworm biology.** The term wireworm is an umbrella name used to describe soil-dwelling larvae that belong to many different species of click beetles (Coleoptera: Elateridae). Wireworms are slender, elongate larvae measuring between ¼ and 1 inch long and yellowish-brown to orange in color. Adult click beetles are also elongate, parallel-sided, rounded on their front and rear ends, and brown, gray, or black in color. When turned upside-down on their backs, adult click beetles return to a normal position using a specialized structure on the bodies that flips them into the air with a loud clicking sound.

Overall, close to 1,000 species of click beetles are known to exist in the United States and Canada. Species complexes vary widely depending on the geographic location and change through time because of changes in cultural practices and use of insecticides. Larval food habits differ among the species: some are herbivorous, some prey on other insects, and some are omnivorous.. Adult click beetles are herbivores, but their feeding is usually not enough to cause economically significant damage. Unlike adults, many herbivorous wireworms are serious pests of agriculture, because they consume underground plant parts, such as roots and tubers, of a variety of different crops.

Similar to other beetles, the wireworm lifecycle consists of four life stages (egg → several successive larval instars → pupa → adult). Some species require up to seven years from the time they hatch from eggs to the time they emerge from pupae. Other wireworms have a one-year life cycle, with adults emerging in the spring following the season when the eggs were laid. For omnivorous species, feeding exclusively on plant material may extend the time period necessary to complete their development.

Adult click beetles are very mobile and can quickly move around by both flight and walking. Economically important species usually lay their eggs in cracks on the soil surface. After hatching, larvae immediately borrow into the soil, where they remain through the end of the pupal stage. After eclosion from pupae, adults dig out to the surface.

Although more sedentary compared to adults, larvae can still move 3-4 feet laterally in the soil. To find suitable hosts, they move towards carbon dioxide produced by breathing of germinating and growing plants. In the fall, wireworms usually burrow deep into the soil to try to get below the freezing line. In the spring, they come close to the soil surface in search of warmth and germinating seeds for food. As the season progresses, they usually follow growing roots back to deeper layers of the soil.

**Habitat preferences.** Before the advent of agriculture, wireworms inhabited grasslands, which still remain their favored habitat. Therefore, field history is often a reliable indicator of potential risks of wireworm damage.  Fields that are coming out of sod, have been previously planted with small grains or grassy cover crops, or are heavily infested with grassy weeds should be treated with suspicion. However, absence of grassy plants in the field's history does not guarantee that it will not be subjected to wireworm outbreaks, but simply decreases the probability that this will happening.

Soil properties, including texture and moisture levels, may affect wireworm abundance and distribution. However, responses to soil conditions differ among different wireworm species. For example, there are species that prefer moist poorly drained soils, while other species do better in light and dry soils. Furthermore, wireworm abundance may be modified by other factors (e.g., availability of food). Therefore, soil type cannot serve as a reliable predictor of wireworm populations.

**Monitoring techniques.** Because of their cryptic habitat, monitoring wireworms is not an easy task. The simplest approach is to excavate, then sift through soil samples to a depth of at least 6 inches. However, wireworm distribution is often clumped even within a single field. Therefore, a large number of samples (more than 50 per field that is less than 20 A in size) are required to make a reliable population estimate, especially when wireworms are not very abundant.

Another approach to sample larvae is using baited soil traps. These consist of a variety of food items (usually grains of some kind soaked in water) buried in the field. These are then dug out 12-14 days later and checked for wireworms. Just as with soil samples, a large number of traps are required for making dependable population estimates.

Pheromone traps can be used to catch adult click beetles of some species. However, no pheromones are yet available for many economically important species.  Furthermore, the link between adult captures and larval damage is not well understood.

Whatever monitoring technique is being used, finding wireworms indicates their presence within a given field. Unfortunately, the absence of wireworms from soil samples or traps does not always indicate their absence from the field in question. Sampling methods currently available for wireworms are generally less trustworthy compared to sampling methods currently available for other insect species. There are also no reliable economic thresholds applicable to the Northeastern United States.

**Management approaches.** Several insecticides are registered for wireworm control in a variety of crops, of which Fipronil appears to be the most effective. Exact application recommendations vary depending on the crop and can be found on individual product labels. Insecticides are usually applied as a prophylactic measure before planting, which is unfortunately likely to result in unnecessary applications on many different occasions.

A number of non-chemical techniques can be useful in reducing wireworm populations. One of the most important techniques is to avoid planting sensitive crops, especially root and tuber vegetables, on fields that either have a known history of wireworm infestation, or were planted to grasses in the past. The inclusion of Brassica crops, such as mustard or canola, into rotation sequence has been also shown to have a negative effect on wireworm populations. In order to protect themselves from insects and diseases, these plants produce special chemicals called glucosinolates, which have insecticidal properties in the soil. Mechanical soil disturbance through plowing, harrowing, or disking may also kill significant numbers of wireworms, but it is usually not sufficient to take care of the problem on its own. Fungal pathogens and entomopathogenic nematodes attack wireworms and have been demonstrated to reduce their damage to some extent. However, their use is often cost-prohibitive.

**Conclusions.** Wireworms comprise a challenging group of pests to control. First and foremost, dealing with a rather diverse complex of different species precludes developing a one-size-fits-all approach. Secondly, cryptic habitats make both scientific research on their biology, as well as monitoring their population in the field a major challenge. Finally, wireworms are well adapted to living in the soil. As a result, grower efforts to maintain healthy soils actually create better conditions for this group of insects. Nevertheless, there are a number of techniques that can be used to successfully manage wireworm populations. The key is not to expect a silver-bullet solution and aim towards overall integration of several different approaches.

## Common Mistakes to Avoid When Planting, Establishing, and Training Spindle Apple Trees

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We are finding that it is critical that you invest the necessary time and effort to manage feathers of a young Tall Spindle orchard if the trees are growing vigorously. For example, all feathers on Fuji (a vigorous apple cultivar) should be tied or weighted down below the horizontal at planting or before mid July to induce cropping and to prevent them from developing into large lower scaffolds. Feathers should not be shortened by pruning during their first year.

The steeper the angle of a feather, the stronger it will grow and the less fruit it will bear. The more horizontal a feather, the shorter it will grow and the more fruit and flower buds it will bear. Therefore, the pendant position of a feather "artificially bent below horizontal" results in a weak fruiting branch instead of a strong scaffold branch with a lot more fruiting potential (more buds are allowed to break and grow into fruitful shoots or spurs).

Fuji or Macoun feathers that are not tied down soon after planting will develop as strong upwardly arched limbs and will be problematic for the close 3-4 feet in-row spacing of the Tall Spindle system. These strong feathers will require severe (and unfortunately unneeded!) limb removal pruning at an early age, which invigorates the tree and makes long-term canopy containment problematic. Early branch management of the more vigorous apple cultivars allows for long-term cropping of many of the original feathers and little invasive pruning for the first 4-5 years of the Tall Spindle system. Even when feathers are tied down below horizontal, it is not uncommon for the new growth of Fuji or Macoun to turn toward vertical after tying. However, the initial tying down "tames" the branch and induces cropping in the second and third year, which will limit branch growth.

Tying is best done within one month after planting but can also be done in June, July, and even until August, (the latter is more difficult due to the presence of new growth and foliage and because the time required to tie down feathers below horizontal may be considerable longer and more expensive). Branch bending can be accomplished by attaching weights to the feather (poured concrete into small cans or cups, a piece of wood, rocks etc.) but selecting the adequate weight for a feather to be bent below horizontal may be difficult. Also, feathers can't always be placed in the desired position. We have found the following materials to be particularly suitable for tying down feathers below horizontal for the Tall Spindle system: (1) a strip of 5/8"-wide Avis-strap nailed or tied from the base of the trunk then split into strands and tied to each of the lower feathers, (2) a pre-cut 20-inch black annealed wire (sold as a 1000 pieces/bundle) each hooked around the feather directly down to the trellis wires, the conduit pipe or bamboo supporting pole, or the main trunk, and (3) a 4-inch long ghent rubber band (six-month-life with 880 rubber bands per bag) where the rubber band is tied on the trunk and the feather is placed through the band when it is stretched out. After about 4-6 months the rubber band stretches and is less effective for strong feathers while Avis-strap strings and the pre-cut black annealed wire are suitable for bending both weak and vigorous feathers.

Branch management research conducted by graduate student Leo Dominguez in Geneva has shown that bending 5 or 10 feathers below horizontal after planting significantly increased the number of spurs developed in Gala, Honeycrisp, Macoun, Jonagold and Fuji Tall Spindle trees. Bending feathers changed their crotch angle, retarded their longitudinal growth, and had a positive influence on cropping.

The tying down of feathers will be more critical if you plant a more vigorous apple cultivar with 8 or more long feathers. After the initial tying down of feathers at planting, new lateral branches that arise along the leader usually do not need to be tied down under NY orchard conditions. Most apple cultivars have moderate tree vigor and if the leader is not headed at planting the lateral shoots arising along the leader are often relatively flat and will bend below horizontal with crop load in the third year. This creates a natural balance between vigor and cropping without additional limb positioning.

We again remind growers that heading of the leader of a young apple tree is undesirable as it removes a significant portion of the tree structure already produced in the nursery. Even if a whip is planted, the leader is not pruned or headed at planting for the Tall Spindle system. Heading the leader disrupts and changes forever the natural growth and branching patterns of a young apple tree on a dwarfing rootstock intended to be grown as a Tall Spindle tree. We instead recommend applying Maxcel to stimulate branching of an "unheaded" whip so a more "calm tree" (without much new upright growth as result of the heading cut) can be produced in the orchard. However, we continue to recommend that growers plant the ideal tree which has a caliper of at least 5/8 inches with 8-10 feathers, each 10-16 inches long starting at a height of 24-26 inches above the ground, well distributed along the trunk, and with wide crotch angles. Feathers that are too low are not usable and must be removed after planting. We recommend that all feathers located below 24 inches be removed after planting for all apple cultivars.

***Note:*** More orchard practices to avoid mistakes will be discussed during the presentation.

# Keys to Successfully Growing Honeycrisp in Nova Scotia

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The introduction of the Honeycrisp apple variety was the most important event in the history of the Nova Scotian apple industry since the loss of the overseas markets following WW II. While sounding like an exaggeration, there has never been a variety in the history of our industry which caused such an immediate reaction in terms of consumer demand and grower profitability.

It all started with the chance viewing of some Honeycrisp fruit in Washington State in 1996 by some of our growers. This chance encounter led to limited plantings that spring and substantial plantings every year since. In 2012 Honeycrisp surpassed McIntosh as our #1 fresh fruit variety in volume; having surpassed all others in dollar value a number of years prior.

The original trees were planted on M-26 rootstock. Failure to manage the vigour properly led us to believe that we should be using larger rootstocks. We then went through an era where a great number of trees were planted on M-7, CG-30, M-4, MM-106, MM-111 and B-118 rootstocks. Eventually we realized that with tighter spacing's, detailed pruning and precise crop load management, more dwarfing stocks were a probably a better choice. The standard plantings now consist of M-26 rootstock planted at 2'-3' x 12-14'; and M-9 planted at 18"-2' x 12-13'. Other stocks such as the M-9 sized Geneva and Budagovsky series are being tried in limited numbers.

All planting systems are now supported. The most common system consists of a two-wire trellis with a leader support attached to each tree. This is usually an electrical conduit, although bamboo and 12 gauge wire has also been tried. The trellis is supported by 12' pressure treated poles driven 30" in the ground spaced every 30-40'in the row. Various four and six wire trellises have been tried, but the growers have tended to be unhappy with the constraints on movement imposed by these systems.

Crop load management is probably the single most critical management exercise. Honeycrisp trees tend to flower heavily and regularly if not over cropped in the previous year. Many blocks now receive a full bloom treatment of Ammonium Thiosulphate (ATS) followed by 3-5 l/Ha Sevin XLR (carbaryl) and 3-5 ppm of naphthalene acetic acid (NAA) at 8-10 mm fruit size. This is occasionally followed by a second application of NAA prior to 15 mm fruit size if necessary. Very little benzyladenine is used as a thinner. Almost all blocks are thinned by hand as well.

Apple scab is not a problem, however Powdery Mildew, Brooks Spot, Flyspeck and Black Rot are. Thus we keep up a regular fungicide program for the entire growing season. Bitterpit is not a severe problem here. Four to six applications of calcium chloride 77% flake is the standard program. Other formulations of calcium are used by some growers with success.

Harvest management is crucial. The fruit starts to colour early in our area due to the cool nights and moderate daytime temperatures. As a result, we are able to start picking when the fruit is quite immature. This allows us to take 2-3 picks before the fruit is over-mature. If it were not for this we would never be able to get over the acreage that we have to pick. We are now using the recently introduced Sinteleia DA (Delta Absorbance) Meter to produce a standard measure of maturity. We do not apply Retain to delay maturity or hold fruit on the trees, as pre-harvest drop is generally not a problem. Some growers have tried under-tree reflective mulch to improve fruit colour, but the results (to me) are inconclusive. All stems are clipped at harvest using lemon clippers.

All fruit undergoes a period of warming or “pre-conditioning” prior to CA or cold storage. This has eliminated (for the most part) ribbon scald and some of the other superficial problems. All fruit is run across a Greefa pre-sort grader and through an internal defect sorter. This takes out any of the fruit with internal browning, a disorder which still shows up in low levels most years. Pack-outs average 85-90% fancy fruit, with the size peaking a little smaller than other areas where it is grown.

While not a simple apple to grow, Honeycrisp seems to like our cool maritime climate and, as previously noted, has done more to change the economics of tree fruit production in Nova Scotia than any other single event in our industries history.

**Native and Invasive Stink Bug Management**

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Results of entomological research indicate that more than 500 species of arthropods feed on apple, 40 of which are present in the Hudson Valley, and may contribute to fruit yield reductions. As more species-specific insecticides are developed and employed, loss of broad-spectrum activity becomes more evident in the damage caused to apple by insect pests that were once controlled by older insecticides having greater broad spectrum residual. One such group of pests is found in the late season phytophagous stink bug complex (Heteroptera: Pentatomidae) comprised of three species. These include the green stink bug (GSB), *Acrosternum hilare* (Say), brown stink bug (BSB) *Euschistus servus* (Say), and the newly invasive brown marmorated stink bug (BMSB), *Halyomorpha halys.* The injury between species is indistinguishable, yet because the injury resembles hail marks and the physiological disorder known as cork spot, it has occurred at varying levels and likely misdiagnosed during packout. Reasons for a recent increase in injury are not completely understood, but changes in chemistries used for pest management (substitution of Delegate, Altacor and neonicotinoids for Lorsban, Penncap-M and other organophosphates), decreased levels of susceptibility, late season crop irrigation during periods drought and introduction of the newly invasive BMSB are believed to be contributing factors to increasing damage by the stink bug complex.

Recently, the stink bug complex has caused serious crop loss to cherry, peach, nectarine, apple and pear in NYS Hudson Valley Orchards. Control with insecticides is difficult as this pest is very sporadic, usually occurring mid to late season, right up to the harvest of stone and pome fruit. Over the past two years the stink bug complex invade orchards late in the growing season when choice of chemical controls is limited by pre-harvest interval restriction (PHI) considerations. Repeat sprays are often required because stink bugs continually migrate to and from the orchards, moving from weed hosts or woodlands. Migration often coincides with drought conditions and is concentrated near orchard edges, near abandoned or unmanaged land typical of the Hudson Valley and New England agricultural landscape. The insect will move into orchards to begin feeding on secondary host weed plants along the orchard edge and weed species in row middles and beneath trees that are flowering and producing seed. As these hosts dry, are killed by herbicides or mowed down, the stink bug moves to apple to begin feeding on fruit.

Research to verify stink bug occurrence and feeding damage on apple by Dr. Mark Brown, USDA entomologist (retired) has found that stink bug feeding injury differs from cork spot in three ways: 1) the edge of the depression on the fruit surface from stink bug feeding is gradual instead of abrupt as in cork spot; 2) the corky flesh is always immediately beneath the skin in stink bug injury, but may not be in contact with the skin in cork spot; and 3) a puncture is always present from stink bug feeding, yet may require the aid of magnification. Brown also found that orchards most likely to experience stink bug injury are those with poor weed control adjacent to woods and/or weedy borders. Stink bugs are very difficult to manage because they: 1) are highly mobile; 2) have a broad host range, including many crops and broadleaf weeds; 3) move frequently between weed hosts and fruit trees; and 4) are therefore not continually exposed to insecticide residues for long periods of time. As in the case of the brown marmorated stink bug, proximity of tree hosts to agricultural commodities play an important role in BMSB infestation levels.

Studies conducted by Drs. H. Hogmire and T. Lesky[3] (USDA) on trapping native stink bug to monitor for presence have indicated that although stink bug presence can be correlated between traps and presence in the tree, traps have not yet been developed as useful IPM tools in determining the timing of preventative measures. This also holds true for the invasive BMSB Tedders trap and newly developed lures used to monitor for presence. Thus the use of scouting observations, are still a more effective method to determine insect presence. The use of trap crops has been considered as a possible strategy to manage stink bug populations. Work done on cotton and soybean have pointed to the preference of soybean as a food source for the stink bug complex. Yet in a 2004 study conducted at Clemson University, the use of soy bean as a trap and kill crop did not significantly reduce damage to cotton by stink bug and does not appear to be a feasible alternative in controlling these pest species.

In a study conducted by USDA-ARS, G. L. Snodgrass et. al. in Stoneville, Mississippi, point to the differences in species susceptibility to insecticides efficacious to stink bug. The pyrethroid bifenthrin was equally toxic to brown and southern green stink bugs, whereas cypermethrin, cyfluthrin, and cyhalothrin were significantly more toxic to southern green than they were to brown stink bugs. They also found that bifenthrin was more toxic to brown stink bugs compared with southern green stink bugs by exposing adults in the laboratory to cotton bolls treated in the field. Organophosphate efficacy studies showed Methyl parathion > Acephate > Dicrotophos > Malathion; and pyrethroid evaluations showed Cypermethrin > Cyfluthrin > Bifenthrin > Permethrin. Yet many of the more efficacious products used on other commodities are not registered on apple in NYS. Newer chemistries with different target sites and modes of action have yet to be tested. Recent studies by Tracy Leskey at the USDA ARS in Kernysville, WV on efficacy of insecticides against the BMSB had shown similar disparity between insecticides. The best performance through residual bioassay studies in control of this species was provided by bifenthrin in the pyrethroid class, dinotefuran in the neonicotinoid class, endosulfan, a chlorinated hydrocarbon, chlorpyrifos, an organophosphate and methomyl in the carbamate class.

In Central Washington State, laboratory studies conducted on field-aged pesticide residues indicated that Asana 0.66 EC (esfenvalerate) was active as a one-day-old residue against native stink bug species but was not very active as a seven-day-old residue. Guthion (azinphos-methyl) was not effective against stink bug species as one-day or seven-day-old residues.

Native stink bug weed hosts include breadgrass, bushberries, curly dock, everlasting peas, milkweed, mallow, morning glory, mullein, mustard, plantain, thistles, vetch, velvetgrass, and other broadleaf plants. BMSB has been found to feed and reproduce on red-root amaranth or pigweed *Amaranthus retroflexus* along with sunflower, *Helianthus annuus*. The addition of enhanced broadleaf weed management, and timely seasonal mowing have been shown to reduce stink bug injury. Conversely, Dr. Mark Brown found late season mowing and poor weed management enhanced stink bug damage to apple. BMSB and the green stink bug are both arboreal, with increases of both species occurring simultaneously in the Hudson Valley in 2012. Both the BMSB and GSB were found to utilize the Tree of Heaven, *Ailanthus* altissima, throughout the growing season. Late in the season BMSB have been found to infest Catalpa, Black Walnut, Sugar Maple, American Ash as host plants and can be observed feeding on tree seeds. The BMSB movement off of woodland trees to late season tree fruit is believed to coincide with the development of the $2^{nd}$ generation adult and loss of viable or depleted resources in woodland host trees.

**Blueberry Nutrition**

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Blueberries are an interesting and unusual plant to fertilize. Relative to most perennial fruit crops, they have low nutrient needs and are sensitive to excessive nutrient levels in the soil. Since the crop value is relatively high there is a natural tendency to apply more types or amounts of fertilizers with the hope of improving yield or quality.

Common Nutrient Problems. Soils vary by region and so do nutritional problems. Most Michigan blueberries are grown on naturally acidic sandy soil with a high organic content. The primary nutrient problem is lack of nitrogen (N). Shortages of phosphorus (P) and potassium (K) are less common, and shortages of magnesium (Mg) and most micronutrient shortages are relatively rare.

Soil pH. Many nutrition problems can be avoided by maintaining a proper soil pH. Optimum soil pH for blueberries is 4.5 to 5.0, but plants usually do fine a little above or below this range. If pH is above 5.5, leaves become chlorotic and plants lose vigor. Very acidic soils (pH < 4.0) can also reduce growth, but soils this acidic are not common in Michigan. Sample the soil to monitor pH before planting new bushes, and every few years thereafter.

Apply sulfur to reduce soil pH. Do not use aluminum sulfate; it is very costly and may injure bushes. Measure the pH to determine how much of a reduction is needed. As a guide, 300, 600 or 1,000 lb of S per acre are needed to reduce pH by one unit (e.g. 6.0 to 5.0) in a loamy sand, sandy loam, or loam, respectively. Apply sulfur a year before planting, since it takes a season to react in soils. Lime may help if pH is below 4.0, but we have not seen benefits from lime applications if pH is higher.

Soils tend to migrate back to their original pH, so if you acidify a soil, you may need to add more sulfur over time. If irrigation water is high in alkalinity or dissolved lime, watering will tend to gradually increase soil pH. Alkalinity levels above 100 ppm are high enough to increase pH.

Proper Use of Nitrogen. Blueberries on most soils require annual N applications for good production. However, excessive rates can also reduce blueberry vigor, yields and hardiness. Careless use of N wastes money and can pollute groundwater or streams and ponds.

Use fertilizers containing ammonium ($NH_4^+$) nitrogen. Use urea if the soil pH is sufficiently low (below 5.0), and ammonium sulfate if the pH is slightly high (above 5.0). Ammonium sulfate is more acidifying (reduces pH) than urea. Mono-ammonium phosphate (MAP) and di-ammonium-phosphate are suitable N sources if P is also need. Blended fertilizers contain other nutrients may also be suitable if most of the N is in the form of urea or ammonium.

Start with low rates on young plants and increase amounts as the plants age, up to 60-70 lb N/acre on mature plants (Table 1). These rates may need to be adjusted by soil type. More N may be needed on very sandy soil with little organic matter, whereas plants on organic or fine-textures soils may require much less N.

| Table 1. Blueberry nitrogen recommendations (lb/acre). | | | |
|---|---|---|---|
| Years in field | N | Urea | Ammonium sulfate |
| 2 | 15 | 35 | 75 |
| 4 | 30 | 70 | 150 |
| 6 | 45 | 100 | 215 |
| 8 | 65 | 150 | 300 |

Apply N during periods of peak demand by the plants. Our recommendation is to apply half of the annual amount prior to bloom and the second half at petal fall. If your site is very cold and winter injury is common, be particularly careful about the rate and application time. High rates tend to keep blueberries growing too late into the fall so the wood and buds will not have time to acclimate to the cold. Also avoid fertilizing after early July as this may also stimulate late growth and reduce hardiness.

Blueberries usually benefit from mulching with wood chips or bark. Mulch materials with high C:N ratios tie up N as they decompose, so more fertilizer may need to be applied to get enough N to the plants. Fresh sawdust and wood chips can have C:N rations of 500:1, so N rates may need to be doubled where these are applied. The C:N of bark and aged wood chips is usually lower, so N rates may not need to be increased quite as much.

Phosphorus. Many Michigan blueberries contain deficient leaf p levels even though soil test adequate for P. When plants are deficient, leaves develop a darker green, purplish color. We need to test some strategies for correcting P shortages. At this point, a reasonable program for P deficient plantings is annual applications of modest rates (25-50 lb $P_2O_5$ per acre). Two useful fertilizers are monoammonium phosphate or MAP (11-52-0) and diammonium phosphate or DAP (16-48-0).

Potassium. K applications are usually not needed each year unless the soil is very sandy. Acute deficiencies cause the margins of leaves to scorch and brown as if they are drying out. Rates of 50-75 lb $K_2O$ per acre correct most deficiencies. Use potassium sulfate (0-0-50) or muriate of potash (0-0-60). Muriate is cheaper than potassium sulfate but the chloride in muriate can injure blueberries. Use some caution if you choose muriate. I would suggest applying this material in the fall so winter precipitation can remove chloride from the soil. Do not use muriate on young bushes or apply more than 100 lb $K_2O$ per year. Potassium-magnesium sulfate or Sul-Po-Mag (0-0-22-11) is a useful K source when magnesium is also needed.

Soil testing is best used in blueberries to monitor soil pH. Soil test nutrient levels only provide an estimate of nutrient supply and do not accurately describe whether bushes are getting enough nutrients. Sample all blueberry soils before planting, and sample established plantings every 2-4 years. One sample is usually need for every 10 acres. Soils can be sampled anytime. Collect soil with a soil probe or auger from at least 20 locations throughout the sampling unit. Sample from beneath the plants to a depth of 8 inches. Combine the soil in a bucket, mix, and remove a portion to send in for analysis.

Leaf analysis is the best way to monitor the nutrition of blueberries. Sample from young plantings every 1-3 years and from mature plantings every 3-5 years. Sample leaves in late July to early August. Collect at least 50 leaves from different bushes throughout the sampling unit. Select healthy leaves from the middle of this year's shoots. Package leaves in clearly labeled paper bags, and send them to a reputable laboratory. Use Table 2 to interpret your leaf analysis results.

**Table 2. Tissue Analysis Interpretation for Blueberries.**

| Nutrient | Deficient (<) | Normal | Excessive (>) |
|---|---|---|---|
| Macronutrients (%) | | | |
| Nitrogen (N) | 1.7 | 1.7 to 2.1 | 2.3 |
| Phosphorus (P) | 0.08 | 0.1 to 0.4 | 0.6 |
| Potassium (K) | 0.35 | 0.35 to 0.65 | 0.8 |
| Calcium (Ca) | 0.13 | 0.2 to 0.6 | 0.8 |
| Magnesium (Mg) | 0.1 | 0.15 to 0.3 | 0.4 |
| Micronutrients (ppm) | | | |
| Boron (B) | 15 | 20-60 | 80 |
| Copper (Cu) | ? | 5 to 20 | ? |
| Iron (Fe) | ? | 60 to 200 | ? |
| Manganese (Mn) | ? | 50 to 350 | ? |
| Zinc (Zn) | ? | 8 to 30 | ? |

**Root Diseases of Blueberries**

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By and large, root diseases are not a big issue for blueberry growers in the Northeast. Most of the diseases that occur affect flowers, fruits, stems or leaves. This will discuss the one disease of economic importance (Phytophthora root rot), four diseases of sporadic occurrence and minor importance (Armillaria root rot, Crown gall, Cylindrocladium rot and parasitic nematodes) and two diseases that have only been recently described (Pythium root rot and Bacterial wilt). Growers should be aware of the latter two newly diagnosed diseases as potential future problems.

*Phytophthora root rot*. The earliest symptoms are dark lesions on the root tissues, followed by eventual rot. The root systems of infected plants become reduced and younger plants can be easily pulled out of the ground. The crown may become discolored which leads to death of the plant. Above-ground symptoms include early leaf discoloration and marginal burn with new leaves being small and premature defoliation is likely. The plants are more susceptible to drought stress because of the reduced root system. The disease often appears in poorly drained sections of the field and in heavier soils. It can sometimes be misdiagnosed as "wet feet". Management of Phytophthora root rot in blueberry depends on an integrated approach. First and foremost, only clean planting stock should be used. Propagation beds should not be watered excessively and should not be irrigated with surface water. When planting, fields should be well drained and if needed, ditches or drainage tiles can be installed to remove excessive surface water or raised beds can be employed. Infected plants may be treated with a fungicide applied to soil or leaves.

*Armillaria root rot*. Infected bushes may display a range of symptoms. Plants may slowly decline in vitality over several years. Infected plants have small, chlorotic leaves and may be more susceptible to drought stress and winter injury than healthy plants. Branches may wilt suddenly, and the entire plant may die within a short time period. The disease may be confined to one area of a field or it may be interspersed throughout the field. The fungus *Armillaria mellea* produces white mycelial fans between the bark and the hardwood, and rhizomorphs (black, rootlike structures that also resemble shoestrings) may be attached to the roots or trunk. The fungus may produce mushroom fruiting bodies at the base of affected plants in late summer. When a forested location is to be used for planting, the soil should be thoroughly disked, and as many root fragments as possible should be removed. The area should be left fallow for at least three years so that inoculum of *Armillaria* is significantly reduced. Infected bushes should be removed and burned. Soil fumigation of areas where infected bushes have been removed helps to prevent recurrence of the disease in replanted areas. Most cultivars are probably highly susceptible to the fungus.

*Crown gall*. Galls are most common at the base of canes or on major roots and are rare on smaller lateral roots. Occasionally, galls form on branches higher in the bush, especially in fields where flooding has occurred. Young galls are cream-colored to light brown; they turn dark brown to black and become rough and hard as they age. Galled areas on canes may appear elongated because several smaller adjacent galls are growing together. Galls vary in size, with a few becoming large. Infected plants may be stunted or weak compared to healthy ones. When older plants (two to five years old) are affected, the foliage discolors prematurely in the summer. Very young plants may be killed outright. All blueberry cultivars are apparently susceptible to crown gall. Thus, the most effective means of control is to establish plantings in uninfested soil with pathogen-free planting stock. Fields where the previous crop was infected should be avoided for two or three years or more. A nonhost crop, such as grasses (grains or pasture) or vegetables, should be grown during this period to significantly reduce the population of the pathogen. Soil fumigation has generally been ineffective in eliminating the bacterial pathogen *Agrobacterium tumefaciens* from field soil. Good cultural practices, including sanitation, minimize the risk of introducing the pathogen into disease-free plantings. All nursery stock should be carefully inspected, and all plants with crown gall symptoms should be removed from the site and discarded. Minimization of wounding of plant tissues is beneficial.

*Cylindrocladium rot*. This is primarily a disease affecting the root systems of blueberry cuttings and nursery plants. Initial disease symptoms are browning or blackening of the stem near the soil line followed by wilting and death of plants. Brown leaf spots and stem lesions with reddish borders may also be observed. Lesions can girdle the stem, killing all tissue above the girdled area. Root lesions and root rot are also commonly observed. Orange-colored perithecia develop on infected tissues under humid conditions. The disease can spread rapidly in a rooting bed. Dead plants are often found in a circular pattern, with disease spreading radially from a point source. Spores of the fungus *Cylindrocladium parasiticum* or *C. calhounii* may infect leaves and stems, and eventually kill entire plants. The root system is often the last healthy part remaining. Sanitation is a key to managing this disease, starting with a new, clean, rooting medium. Frames, trays, and pots should be cleaned before reusing them. No cultivars are known to be resistant to the disease. Moisture should be managed to reduce relative humidity and water splash as much as possible. Diseased cuttings or plantlets should be removed as quickly as possible and remaining plants should be treated with an effective fungicide.

*Parasitic nematodes*. The majority of plant-parasitic nematodes associated with blueberry are ectoparasites, which use their stylets to feed on root epidermal and cortical cells, but do not enter roots. Most ectoparasites preferentially feed on root tips, thereby disrupting root elongation, causing ‘stubby’ roots or witches-broom symptoms, and reducing overall root growth without necessarily causing noticeable lesions or necrotic areas. Sheath nematodes (*Hemicycliophora*

spp.) can cause terminal root swellings or galls on the roots. Lesion nematodes (*Pratylenchus* spp.) are endoparasites that use their stylets to perforate cell walls and completely enter fine roots, causing localized lesions that can become infection courts for opportunistic fungal pathogens. When roots have become infected by many nematodes, lesions coalesce, causing girdling and dieback of fine roots. Root-knot nematodes are endoparasites which enter roots and establish permanent feeding sites. As the female nematodes mature, they become enlarged and root tissue around them swells, resulting in formation of the characteristic galls or ‘root-knots’. *Meloidogyne carolinensis* is the only root-knot nematode known to infect blueberry. The ultimate effect of all plant-pathogenic nematodes is impaired root functioning, and above-ground symptoms of nematode damage are usually non-specific and manifested only as patchy areas of poor growth that are difficult to distinguish observationally from the effects of poor nutrition or water availability. Plant-parasitic nematodes alone generally do not cause plant death.
Because there are no obvious aboveground symptoms of nematode damage, diagnosing the possible role of nematodes in plant disease depends entirely on analyzing soil and root samples for the presence of plant-pathogenic species. Damage to roots in one year may not be manifest as reduced growth or yield until several years later, or after additional stresses such as drought are imposed upon the crop. Some nematode species (*Xiphinema* spp.) are capable of vectoring viruses that infect blueberry. Only the preplant fumigants are currently labeled for nematode control in blueberries.

*Pythium root rot*. This disease was found in a field in Michigan in 2009. Affected plants were stunted with yellow leaves and defoliated. Plants had declined in productivity over several years and some plants died. Roots in these plants were shown to have decay and necrosis, and roots systems were reduced in volume. The fungal pathogen, *Pythium sterilum*, had previously been found in infected plants in Georgia, Oregon and British Columbia. Very little is known about the disease, which can very easily be confused with Phytophthora root rot. Control strategies would likely be very similar to the latter disease.

*Bacterial wilt*. This disease was only discovered in New Jersey in one field in 2012, but it is worth reporting because it is a potentially devastating disease wherever it may occur in the future. The field of ‘Bluetta’ plants exhibited symptoms of wilting and rapid cane death. Entire bushes died in a short time period. Leaves exhibited marginal leaf necrosis. The bacterial pathogen, *Ralstonia* (formerly *Pseudomonas*) *solanacearum* was present in the vascular tissue and systemic in the plants. This bacterium is an effective soil colonizer and can survive for many years in the absence of a host plant, and it has a wide host range. No chemical controls are available and very little is known about the disease in blueberry. The plants in the affected field were immediately removed and burned and sanitation was employed to prevent any spread of the bacterium.

**Management of Blueberry Fruit Fly**

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With new invasive insects (like spotted wing drosophila) threatening our crops, it is easy for growers to slip back into relying just on chemicals to handle insects. I feel that an integrated pest management approach really is best, and that's especially true with this insect, blueberry fruit fly. I recommend a combined approach: 1) monitoring for the insect (traps) 2) using preventative & suppressive measures (destroy nearby wild hosts, keep bushes well pruned) and 3) applying controls **only** if the traps show that there is a need. Since most New England highbush blueberry growers rely on pick-your-own marketing, I have followed the lead of my colleagues at the University of Maine, in switching to the common name blueberry fruit fly, for *Rhagoletis mendax*. I think the common name "blueberry maggot" is too unpalatable for many consumers. Good public relations is another reason to monitor with traps. When PYO customers see insect traps (especially those with an accompanying sign, explaining that they are used to reduce dependence on spraying) they react favorably. Seeing sprayers or smelling pesticides in the planting tends to give customers the opposite image…farmer Rambo.

Life Cycle and Injury

Until the appearance of spotted wing drosophila in 2011, blueberry fruit fly (BFF) was the most serious insect pest of highbush blueberries in most of New England. The insect has just one generation per year, and overwinters as a pupa in the soil. The flies (the adult stage) are present from late June through August. In sites with extremely high populations, a few adults are present as late as early September. Soon after emerging, they mate. The females feed for a few more days, and then begin laying eggs. They attack ripe and ripening berries, laying eggs just under the skin of the fruit. The eggs hatch into white maggots (sorry…I had to use the m-word) that consume the flesh, turning the fruit mushy. Compared to the larvae of spotted wing drosophila, BFF larvae are more plump, and larger. Maximum size for BFF larvae is about 6mm (3/16 inch). When they are mature, they drop into the soil and pupate. The next June, the cycle begins again.

Trapping to Monitor the Flies

BFF population size varies tremendously from site to site. In our recent 3-year trapping survey, we found many sites that trapped none, a few that had some, two that trapped hundreds, and one farm that trapped thousands of adults. I recommend to all blueberry growers that they use traps to monitor BFF. The traps are easy to use, and insect identification is easy. We evaluated three basic traps, with and without added odor lures. In 2009 & 10 we also tested the "curve ball" traps, which are not commercially available. Traps work well if they are hung properly. Poorly hung traps are almost useless, except at sites with very high BFF populations. Don't mis-understand: these are not to control the pest. They are to monitor the insects: tell when they are present, and give a relative idea of abundance.

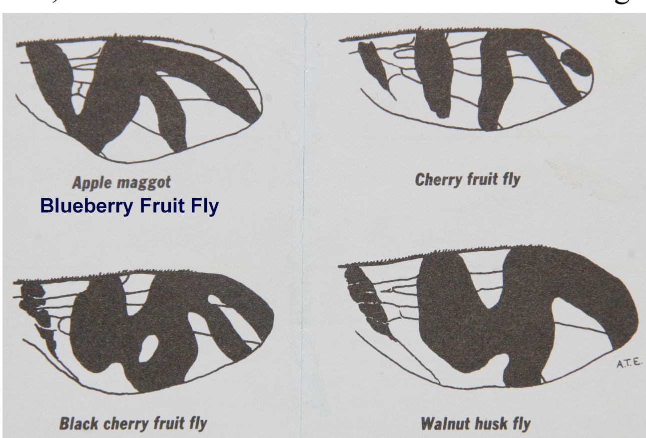
**Red Spheres**: these are relatively heavy, so require a strong supporting branch. They are good at trapping, but the flies are a little difficult to identify against the dark red color. You can use one for many years, if you take it down in September and store it properly.

**Green Spheres**: these are also relatively heavy, so require a strong supporting branch. They are fairly good at trapping, and the flies are a little easier to spot against the green color. Like the red spheres, they can be re-used for years if stored properly.

**Baited Trece Yellow Rectangles**: These are excellent at trapping the flies WHEN HUNG PROPERLY, and are fairly good when hung vertically. The flies are very easy to identify against the yellow background. The traps are lightweight, so they must be anchored to keep them from blowing against foliage and fruit. An odor lure is already mixed into the sticking agent on these, and they arrive pre-stickied, folded up. They are useful for only 2 weeks in the field. I store mine tightly sealed in a plastic bag, in the freezer, and take them out when I'm ready to hang them.

More information on the sticking agents, how and when to hang the traps, and where to buy them is in my publication, listed at the end.

Check traps weekly for the blueberry maggot flies, and write down the data. Keeping records helps for decision-making in future years. I remove each fly as I count it, so the number will be accurate. Check traps weekly during the growing season. Soon this monitoring will tell you what the particular pattern of activity is in your planting. The "average" peak is about July 8 – 12th, but some sites with lots of late varieties might have a later peak.




You recognize BFF adults by the small white dot on their backs, almost between the wings, plus the particular pattern of black bands on the wings. They are small flies, about 4mm long (1/6 inch). A large magnifying glass may be helpful to identify them. When the flies are present, you know they can be attacking your fruit. There isn't a particular number of flies that triggers action. You be the judge of that.

Controls:

Consult the current New England Small Fruit Management Guide for details on pesticides. There are both organically-approved pesticides and synthetic products. "Surround" is listed for "suppression" of BFF, so to me this implies that it isn't too effective. The peak of BFF egg laying is a bit before the maximum "pressure" from spotted wing drosophila, but it may be common for the two to occur simultaneously. Most materials that are registered to control SWD will also control BFF.

Preventative and Suppressive Measures:

Eliminating nearby unmanaged blueberries will help reduce the problem from this and several other blueberry pests. If you avoid dumping "spoiled" berries nearby, that will help, too. Keeping the fruit picked will also help. Plants that are properly pruned will allow good penetration of spray materials, and those pruned bushes may be less preferred by spotted wing drosophila.

Helpful Sources of Information:

1) Using Traps to Monitor Blueberry Fruit Fly in New Hampshire (2012)
   http://extension.unh.edu/resources/files/Resource002077_Rep3071.pdf

2) 2013-14 New England Small Fruit Pest Management Guide.

3) Magnifiers & Other Visual Aids for Insect Monitoring (2013)
   http://extension.unh.edu/resources/files/Resource003343_Rep4814.pdf

4) Compendium of Blueberry and Cranberry Diseases APS Press [yes, it covers insects, too]\

5) New Hampshire IPM newsletter http://extension.unh.edu/Agric/AGPMP/IPMNews.htm

6) NH Fruit Pest Update Telephone 603-862-3763 continuous, April 1 to mid-Sept each year

# Keeping the High Tunnel Full of Cuts Year-round

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High tunnels are unheated greenhouses that commonly consist of a metal frame covered by clear polyethylene plastic. They have become popular in recent years to extend the growing season on vegetables, cut flowers and to protect these and berry crops from adverse weather during that season. In this presentation, examples of cut flower growing schemes in high tunnels will be presented and initial experiments with tender perennial cut flowers that have been overwintered successfully in such structures will be shown.

As a season-extension tool, the unheated high tunnel typically allows three weeks earlier planting in the spring, and with low tunnel protection in the structure, a similar period of continued growth in the fall, compared to outside. This allows the transplanting of cool-adapted cut flower crops such as stock (*Matthiola incana*), sweet pea (*Lathyrus odorata*), campanula and larkspur as early as mid-April. As these early crops mature and can be pulled out, late-season crops of snapdragons, zinnia and calendula can be productive the rest of the season.

Alternatively, crops that grow well in the high temperatures of the summer tunnel could be planted later in spring and produce cut stems into fall. Lisianthus, celosia and trachelium are good candidates for that purpose, producing taller and more numerous stems over the extended season.

Additional species that could be of interest for fall harvest include pumpkin-on-a-stick (*Solanum integrifolium*), which is harvested for the mature red miniature pumpkins borne on the stem. There are now also many showy peppers (*Capsicum annuum*) varieties that look attractive in a fall arrangement. The frost protection of the high tunnel also allows for growth of late-flowering varieties of chrysanthemum, both pompom and spray types.

It has become apparent that the high tunnel can also serve as a valuable aid to overwintering tender species that could not be successfully grown in botanical zones 5 and 6. We have recently found that pineapple lily (*Eucomis*), a genus native to South Africa, can survive and thrive in a high tunnel, and produce attractive flowers with considerable consumer appeal. A vase life of three weeks adds to its desirability.

Other overwintered crops that look promising in the high tunnel are tulips, which bear early and tall high quality flowers from fall plantings. Flowering is advanced by at least 2 weeks compared to outside. We are also currently experimenting with lesser-known bulb crops such as *Brodiaea* and *Fritillaria*.

In summary, growing cut flowers in a high tunnel can provide for an extended flower marketing season, and allow for production of flowers that could not be grown in the outdoor climates prevailing here.

## Starting a Specialty Cut Flower Farm – What to Grow and Where to Sell

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For over ten years, Michael has worked his way around the farming and cut flower industries to expand his knowledge for a solid foundation in the Specialty Cut Flower Marketplace. Join Michael as he shares his experience and helps you answer two big questions that arise when starting a cut flower farm.

### WHERE WILL I SELL?

There are many markets for selling specialty cut flowers and you need to find the markets that best fit your personality and your farm.

**Roadside Stand:** Location is the biggest decider in how successful a roadside stand can be. A busy street versus a low traveled country road can make a huge difference. Beyond physical location you will need an inviting location with a clean and attractive stand. Our farm shares property with a vegetable farm and we found we had better sales if both of us had a well-stocked stand. Our second season the vegetable farm was not very active in the stand so we saw a big decrease in sales at the stand.

**CSA Shares:** A flower only CSA or Flower Club is a new idea for many consumers. Subscriptions can be promoted to homeowners, offices, salons, B&B's and are great to promote as birthday, anniversary or holiday gifts. We had an opportunity to offer our shares along side a fruit and vegetable CSA from a nearby friend and had good success with that. Select the right amount of weeks to fit your growing season that also allows you some flexibility.

**Event Flowers:** The move towards local flowers has built a big calling from brides and other event planners. If you have a design background and the patience of dealing with brides and mothers of the brides this can be a good sales route. Just keep in mind this is very time consuming in both the planning, designing and set up of the flowers so make sure you are not giving too much for too little. A lower maintenance option is buckets of loose flowers or selling of bunches of flowers for the D-I-Y customer.

**Farmers Market:** Farmers' Markets offer many opportunities to farmers, but can be used in many different ways. Some farms use a market for simply that marketing and building relationships. Other growers who focus on sales to florists may use a market as a way to move large quantities of flowers or flowers that are not at the quality florists are looking for. For our farm we did not have the flexibility for a weekend market and weeknight markets in our area are not busy enough to make the time worthwhile for us. As business people we really tried to push away from the low prices of our competitors and found that even with our higher pricing, that is something to keep in mind when selling at markets. Home grown does not mean cheap.

**Direct to Florist:** This is the market place we are looking to make the main focus of our business. With retail and wholesale background we have familiarity with the needs of florists. Local growers can offer a quality and variety of products that florists would love to work with but do not have easy access to. It can take some time to get into florist and build those business to business relationships but we found that with stopping at two to three florists we could bring in the same amount of money compared to sitting at a market for 4 hours. One key for us with florists is quality. Sometimes our biggest moneymaker was leaving a sample of products for them to try.

## WHAT WILL I GROW?

Developing an answer to "**WHERE WILL I SELL?"** will help determine what you will grow. Each marketplace has a calling for different flowers. Inquiring with local florists on their interest in needs is helpful when going after that market. If you are doing mixed bouquets you can really get away with doing a large variety and then slimming down your options in future seasons.

As a grower you will need to make the decision between annuals, perennials and woodies as well as to start your own seed or buy plants. Deciding on both of these is dependent on your market, available land, indoor growing space and the amount of time and energy you have to put into your business. A resource for helping make this decision is the Association of Specialty Cut Flower Growers (ASCFG). This is a group of growers and educators compiling, publishing, sharing information to help make each of us a better grower and business person. Each year members trial, nominate and vote for cut flower of the year which now include a new fresh, woody, dried and bulb crop each season. Visit www.ascfg.org to find out more about the association and to see what growers have said are their favorites.

### Great Flowers To Start With

Each of these can be either direct sown or the corm can be planted directly into the ground, with minimal weeding, fertilizer and watering you can harvest a luscious blooms.

***Amaranthus Cosmos Sunflowers Zinnias Gladiolus Broom Corn***

### 15 Popular Specialty Cut Flowers

When you get more adventurous and your confidence growers this list is of 15 popular specialty cut flowers that are commonly grown by specialty cut flower farmers.

***Sunflowers Lisianthus Snapdragons Celosia Zinnia Dianthus Ageratum***
***Statice Lilies Dahlias Hydrangeas Larkspur Grasses Peonies Gomphrena***

### Cut Flower Of The Year Winners

These are all winners of Cut Flower of the Year from ASCFG (Visit www.ASCFG.org for a full listing) but I only included my favorites that I have grown or have seen successfully grown.

***Zinnia 'Benary's Giant' Rudbeckia 'Indian Summer' Eustoma 'Echo' series (Lisianthus)***
***Ageratum 'Tall Blue Horizon' Dianthus 'Amazon Neon Duo' Eryngium 'Blue Glitter'***
***Ilex verticillata 'Winter Red' (Winter Berry) Hydrangea paniculata 'Limelight'***
***Zinnia 'Uproar Rose' Lisianthus 'Mariachi Carmine' Viburnum 'Snowball'***
***Physocarpus 'Coppertina' (Nine Bark) Paeonia 'Sarah Bernhardt'***
***Lavendula xintermedia 'Grosso' Sorghum bicolor Panicum 'Frosted Explosion'***

## Techniques to Maximize Production of Sunflowers, Larkspur and Delphinium

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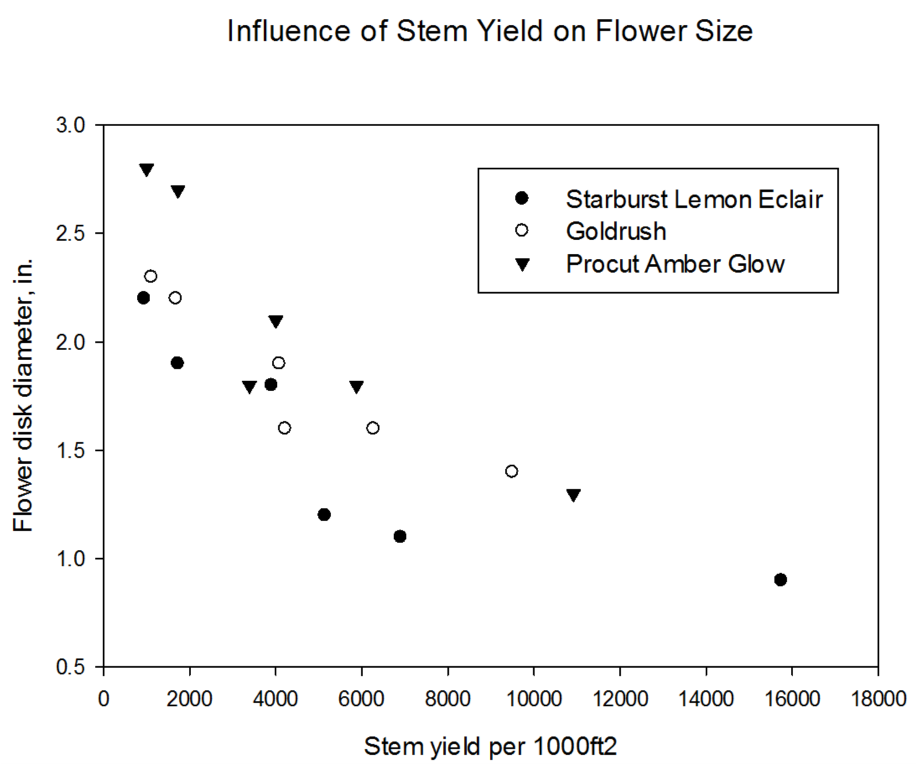
Increasing the yield of marketable stems of major cut flowers is a central goal of most cut flower growers. Such yield improvements may however come with the need for more inputs in materials or labor, and thus need to be considered carefully. We will present three cut flower crop examples that mostly avoid those problems and should be considered by growers.

Sunflowers grown as cut flowers are classified as either single stemmed or branched varieties. Yield of branchless varieties is determined by plant population, but can be increased by 3 to 5 times if the growing point is pinched out when the plants are in the seedling stage. Branching types will produce several stems, but also develop a first flower on the main stem, which, if harvested with a stem of a foot or longer, causes many of the potential branches to be removed. We have found that if these are also pinched early, long and profuse branches are produced. With the increased number of stems per unit area resulting from pinching, the size of the flowers decreases (Fig. 1).



If the plants are already crowded before pinching, the flower size may become too small to be acceptable commercially. On the diagram, if the commercial minimum flower size is set at 1.5 in., the maximum stem number should not exceed 6000 stems per $ft^2$.

In our research over 3 years, we have also found that sunflower varieties vary widely in their response to pinching. 'Procut Lemon' is reluctant to branch, and shows no benefit in being forced to branch; 'Sunrich Orange' is also adversely affected by pinching, developing a lower leaf disease that decreases the production of branches. In general, the branching varieties like Gold Cup and the Starburst lines respond well, and produce good yields when pinched early.

Larkspur (*Consolida*) has for us been a productive early season crop in the high tunnel. It grows well in cool conditions, and can survive well when sown directly in the fall, without secondary low tunnel covering. It can also be transplanted early in the spring to the high tunnel beds. In a comparison of the two planting methods, we found that plants in the two plantings produced similar yields, but the fall-planted larkspur flowered on June 6, two weeks earlier than the spring-planted lines. Fall planting is also easier since it does not require the use of a greenhouse to produce the seedlings in the spring.

Table 1. Yield, stem length and date of flowering of two varieties of larkspur, either sown directly into the high tunnel in the fall, or sown in the greenhouse in spring, and then transplanted into the high tunnel.

| Sowing/Transplant date | Plant height in. | Stems per plant | First flower date |
|---|---|---|---|
| Oct. 24 | 28 | 5 | June 6 |
| Feb. 13, April 8 | 24 | 4 | June 20 |

Perennials grown for use as cut flowers can be judged both on their productivity in the first year, but also on whether the plants survive to continue providing usable stems in succeeding seasons. We have been trying to overcome a decline in the plant population of certain delphinium varieties using several methods, but have found that choice of variety is the best indication of plant survival. Accordingly, we planted seven delphinium varieties in spring of 2013 in a field that had grown this species previously. We monitored plant stands throughout the season, and found distinct varietal differences (Table 2). The study indicates that choice of variety can be an important criterion for sustained productivity over time. We will monitor yield and stands in this trial over several years.

Table 2. Differences in plant stand among seven delphinium varieties planted in the field in 2013, averaging three replications and four sampling times.

| Variety name | Average plant stand, percent |
|---|---|
| Centurion White | 99.4 |
| Centurion Rose | 97.2 |
| Aurora Blue | 93.9 |
| Pacific Giant Percival | 93.3 |
| Candle Blue | 91.6 |
| Guardian Blue | 79.4 |
| Pacific Giant King Arthur | 69.4 |

**Taking Cut Flowers from Sideshow to Main Event:**
**The Tipping Points of Growing Our Flower Business**

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We wanted flowers to be a serious part of our business and income, so we decided to take flowers seriously. In 2006 I became a partner in the flower business. In 2011 I became the sole proprietor.

Malcolm Gladwell's book *Tipping Point: How Little Things Can Make a Big Difference* has inspired me to share some of the specific changes we have made to our flower enterprise. Each of these changes has led to more improvements than we anticipated.

**Tipping point: We set up the cut flower business as separate from the veggies and plants.**

Different folks give the enterprise fresh energy for planning, growing, and selling. The variety of crops required to have a constant supply of blooms for 3 seasons requires similar intellectual attention to a mixed vegetable crop repertoire. I am lucky to have access to the land, greenhouses, markets, branding, and equipment from my folks' farm, but my attention is almost always on flowers.

> We cut our first stems of daffodils mid-April and our last stems of spider mums around December 1st. This also allows our customers to rely on our having some kind of floral beauty for them though our whole market season, and it helps me know I can build event flowers around whatever's seasonal.
>
> We plan for succession plantings. We went from 3 plantings of sunflowers to about 8. We grow 3 waves of zinnias. You wouldn't plant just one crop of lettuce and expect it to meet your demands for the summer. Sunflowers are similar (but less washing!).
>
> Having someone almost always thinking about flowers has led to planting more perennial crops to fill in gaps in annual production. Many of these shrubs offer greenery which adds more interest and texture to our bouquets and designs. We continue to invest in perennial crops like peonies, hydrangeas, physocarpus, and daffodils.
>
> Keeping the income of the flower business separate is a great way to appreciate the value of the flower enterprise.
>
> I used to help with the veggie harvest, but now that I'm a full time flower lady, I can plan to make a wedding delivery on a Friday if necessary, and keep my head in the flower game.

Our flower tools are mostly used just for flowers, that way we have enough of the right sized buckets and really sharp snippers. We then don't dull other tools for cutting the eggplant, trimming the onion tops, and picking pumpkins.

Having separate staffing means fewer negotiations to get jobs done. I now have some of my own employees, that way I can prioritize things like weeding the eucalyptus instead of putting that in the context of everything else that needs to be done on the farm.

**Tipping point: We joined the Association of Specialty Cut Flower Growers.**

The Bulletin Board alone is worth the membership fee, but the *Cut Flower Quarterly* magazine is also a valuable resource, not to mention regional meetings, networking contacts, and national conferences.

This reframed the way we thought about flowers as a business. We went from growing a nice mix of flowers for bouquets to being flower farmers. Mom calls this "admitting what business you're in."

Discussions at ASCFG meetings and on the Bulletin Board also led me to making multiple bouquet sizes and often rethinking our pricing schedule. ($12 is the new $10!)

I also learned from bulletin board discussions about starting conversations about event flowers with a professional tone.

**Tipping Point: Wedding flowers are a service, not just a product:**

Polly Hutchinson, active member/officer of the ASCFG, said something at a flower meeting that totally changed the way I think about wedding flowers. Folks were casually talking about how annoying and cheap some brides are about their flowers. A naïve me said something like "Well, I think people want to buy flowers from a farm because it's so much less expensive." And Polly said "We try really hard to make sure that's not the case."

I felt empowered.

We finally recognized that making a bridal bouquet is different than making a bouquet to offer for sale at farmers' market. Even if they have similar ingredients, there are many more emails and much more care and stress wrapped up in that bridal bouquet.

To take away some of the stress of designing for weddings I have set up connections with floral wholesalers, so if I just plain need something red or yellow or blue I can get it. I have my local connections to call first, but this way I don't lie awake wondering whether any of the red dahlias will happen to be open that week, or worry my delphinium finally succumbed to powdery mildew. This has also enabled me to take on weddings in May and June and late September and October, times when the flower supply is unpredictable.

We have created a system for handling wedding inquiries and giving brides the attention they need for their initial consultation. This requires a lot of time for correspondence. We love email for this. (There's a record of it and you can answer emails early or late.) Wedding deposits also provide some very appreciated winter cash flow.

In writing a wedding estimate I have more than once found myself thinking "well, if I have enough of my own dahlias/lisianthus/sunflowers/peonies, it won't cost as much as if I have to buy them in." Flowers shipped in are almost never as good as the ones we grow that have never been in a box and on trucks and planes. So instead of charging more if disaster strikes, we have learned to fully value the flowers we grow from the outset.

We have also developed a system for selling flowers to brides who want to arrange their own wedding flowers. Most people can't just show up at a Saturday market for flowers for a Saturday wedding. We sell a mixture of flowers in all colors or certain colors in 2-gallon buckets. These flowers are reserved with a deposit and can be picked up at the farm or delivered. This model has worked well and is way less time consuming than explaining every flower we might have available and getting a target volume for each one and then worrying if I might have enough bunches of lime zinnias or whatever.

I've made offering delivery a priority. Most people cannot fit their whole flower order into their mid-sized sedans. I have learned to value this time and charge for this service.

**Tipping Point: We built a cooler just for flowers.**

Fruit and flowers aren't friends; they need separate space. A cooler also lets you cut more marketable stems and keep the quality up.

We used to harvest on Tuesdays and Fridays for markets Wednesdays and Saturdays. Having cooler space has allowed us to pick flowers when they're just right and hold them for our market days.

The flowers that require the most constant cutting attention are tulips, peonies, lilies, and sunflowers.

To maintain the highest quality product, we continue to learn the proper stages of harvest and post-harvest treatments. The happier the flowers are the happier our customers are.

The cooler is also very important for conditioning any flowers we do end up buying in for weddings and also keeping our finished products fresh before pick up or delivery.

**Tipping Point: We devoted both hoophouse and greenhouse growing space to flowers.**

Greenhouse structures are great for season extension in spring and fall. They also are especially useful for protecting delicate floral tissue from rain and wind. We have rotated one of our hoophouses into and out of flowers each year, and will add another this year.

It's easier to trellis things in a hoop house. (Sweet Peas!)
It's nice to have a place to harvest or weed or work when it's raining.
We double crop our plant greenhouses with lisianthus, asters, dahlias, and fancy mums.

**Our three newest important additions:**

A guillotine for cutting stems has saved our fatigued hands and made for happy stems.
A light box for photography has facilitated better documentation of our design work.
A new gator has made for hassle-free harvesting.

## Putting a Good Quality Crop into Storage

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The traditional New England diet has relied on storage vegetables for a long time – potatoes, carrots, cabbage, rutabaga, winter squash, etc. Modern technology is making it possible to maintain very good quality of vegetable crops in storage (refrigeration, insulation, ventilation, humidity controls, modified atmosphere, etc.)

For best results in storage, however, it is important to note that even the most advanced storage technology cannot be a replacement for mediocre quality from the field. Most storage consultants will stress that "a storage is not a hospital". Or, "Junk In, Junk Out!"

For best results with storage crops remember the following:

**Use Storage Varieties**
Some varieties have been designed for fresh market use, but these varieties typically do not store well. Fresh market varieties typically grow quickly, have high water content, and relatively low solid content. Storage varieties, on the other hand, grow rather slowly, have high solid content and relatively low water content. Storage varieties also have higher levels of antioxidants (to protect them from decay during the winter season….)

**Store only Healthy Crops**
There are many organisms that will try to destroy your storage crops during the winter. There is no need to speed up the decay by putting diseased product in storage. Diseased crops break down quickly, generate heat and moisture that will reduce storage life of the rest of the crop, spread disease onto healthy product, and will just create a mess.

**Store Slightly Immature Product**
Once produce is fully mature, it will begin the physiological process of aging. In this aging process, tissues begin to soften, leaves begin to yellow, and decay begins to set in. By harvesting slightly immature produce you can preserve the mature look and maintain good quality for a much longer time.

**Pre-conditioning**
You cannot dig potatoes on a hot day in August and expect them to store. Piling potatoes with high pulp temperature into a storage will have you holding your nose in few weeks – the potatoes will break down with soft rot (very smelly!).
Obviously, pre-chilling crops in preparation for cold storage makes sense. Harvest storage cabbage late in the season, when the weather is cold. Harvest carrots when soil temperatures are low. Harvest onions when there is still good drying weather in the fall – and cure onions outside in boxes to make sure they are nice and dry. Bring the onions inside after the weather gets cold. Cure winter squash to make sure the rind is strong and hard.

**Bring Mother Nature Inside**
Savoy cabbage stores very well when you harvest it with the snow still on – much cheaper than icing or running the cooler! Chinese cabbage stores well in some snow, as well. Harvest carrots gently and leave the dirt on – the dirt helps modulate humidity levels in storage. Same goes for beets, potatoes, celeriac, parsnips, etc.

**To wash or not to wash?**
Yes – washing prevents some staining from soil. But – washing also creates small wounds that can easily be infected by fungi and bacteria. Furthermore, the skin or rind of vegetables can contain phenolic compounds that will oxidize when the skin is damaged, and the oxidation products can create discoloration or staining, and can sometimes create off-flavors.

Free moisture (from washing, or from condensation) is not a good in a storage – many fungi and bacteria need a layer of moisture to invade their vegetable host. Keep the produce dry (but keep the relative humidity high!), and provide some ventilation and fresh air from time to time.

**Trim after Storage**
There is no need to trim and clean produce before putting it in storage. It is better to avoid cutting and creating wounds as much as possible. The wrapper leaves on cabbages help prevent superficial damage to the head itself, leaving a bit of leaves on the beets is OK, trim rutabagas just enough to remove the leaves, but leave the necks intact.
Trimming gives you something to do in winter – but you only have to trim as much as you would like to sell that day.

**Maintaining Storage Crop Quality at Pleasant Valley Farm**

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Pleasant Valley Farm is located in a valley in a rural town 25 miles northeast of Saratoga Springs, New York and we have been operating it as an organic fruit and vegetable farm since 1988. We have two children, Robert (age 21) and Kimberly (age 18) who were home-schooled, attend college, and are an integral part of running our family farm. We own 60 acres and rent our neighbor's 120-acre farm; we use a total of 5 acres for vegetable production, 1/2 acre for large fruits and 1/4 acre for small fruits, and keep another 3 acres in cover crops for rotation. We grow a diverse selection of more than 40 types of vegetables and fruits with organic methods (certified through Certified Naturally Grown www.naturallygrown.org) for retail sales at three area summer farmers' markets, two winter farmers' markets, and a small amount is sold to several local restaurants.

Along with winter growing of greens in three unheated high tunnels, we utilize our 20ft by 30ft root cellar, buried on 2 ½ sides under our large barn, to store unwashed crops, which are sold all winter/spring. In the spring of 2007, a specialized cooling system was installed in the root cellar, which maintains a constant high humidity and cold condition, about 95% relative humidity and 34-37 degrees F. We increased production on crops that will store well for winter sales, and are learning more and more varieties of produce that lasts well under the right conditions. November harvested kale and swiss chard stored for over 6 weeks, and late November lettuce, cut and crated, will hold for 4-5 weeks in very good condition! Cabbage and leeks are lasting well into March, and the carrots, beets, and potatoes, will look near perfect in mid-summer when the new crops come in. Other crops we store are: radishes, celeriac, turnips, rutabagas, brussels sprouts, celery, kohlrabis, and cauliflower. Our root cellar holds about 24 tons of produce with a value of over $85,000. The $10,000 cooling system paid for itself in a matter of months!

Other crops that we store for winter sales are winter squash, sweet potatoes, onions, shallots, apples, and garlic, each in their own preferred environment. Winter squash and sweet potatoes are harvested in September, and then cured at 85-90 degrees for 4-6 days before cooling and storing for many months at 55-60 degrees and 50-70% humidity. We store these 2 crops together even though sweet potatoes prefer a higher humidity (85-90%). It is difficult to store each crop at their optimum conditions since we have over 20 varieties of produce for winter storage, so we compromise for what works satisfactorily.

Onions and shallots are cured in the field or on racks in our barns, then moved to our walk-in cooler with conditions at about 33-34 degrees and 65% humidity. Garlic is racked and dried in our high tunnel before storing in ventilated crates and then moved to the walk-in cooler. When the garlic starts to degrade, we dehydrate it and sell it as dried garlic powder. Our apples, because they give off gases and should not be stored with vegetables, are kept in a local orchard's cooler.

Our favorite device for helping to monitor all these different storage areas is our Davis Vantage Pro 2 (www.scientificsales.com), which has wireless temperature and humidity monitoring devices, each with the data transmitted back to the base unit in our house. We constantly monitor each location: root cellar, squash storage, and cooler, as well as the high tunnel, and outside conditions; alarms can be set in case of malfunctioning equipment. Temperature monitoring devices/alarms should be a top priority because of the value of the stored crops; not spending this minor amount of money would be penny wise and pound-foolish!

Storing crops and having them keep for long term with good quality, involves not only the correct environmental conditions, but also making sure that the crops we store are of good quality and few diseases when going into storage. Monitoring each crop, sorting out bad ones regularly, and maintaining optimum conditions is critical. Pre-cooling the crops or harvesting them for storage after the weather has cooled is important, and using varieties designed to store is helpful, especially for long-term storage.

**Paul Arnold--Pleasant Valley Farm** **DEC 2013**

**STORAGE RECOMMENDATIONS AND STORAGE LIFE**

| VEGETABLE | TEMP F. | RELATIVE HUMIDITY | STORAGE LIFE | HIGHEST FREEZING TEMP. |
|---|---|---|---|---|
| Beet, topped | 32 | 98-100 | 4-6 mon. | 30.3 |
| Brussels sprouts | 32 | 95-100 | 3-5 weeks | 30.5 |
| Cabbage, late | 32 | 98-100 | 5-6 mon. | 30.4 |
| Carrot, mature | 32 | 98-100 | 7-9 mon. | 29.5 |
| Celeriac | 32 | 97-99 | 6-8 mon | 30.3 |
| Celery | 32 | 98-100 | 2-3 mon. | 31.1 |
| Garlic | 32 | 65-70 | 6-7 mon. | 30.5 |
| Kale | 32 | 95-100 | 2-3 weeks | 31.1 |
| Kohlrabi | 32 | 98-100 | 2-3 mon. | 30.2 |
| Leek | 32 | 95-100 | 2-3 mon. | 30.7 |
| Lettuce | 32 | 98-100 | 2-3 weeks | 31.7 |
| Onion, dry | 32 | 65-70 | 1-8 mon. | 30.6 |
| Potato, late | 38-40* | 90-95 | 5-10 mon. | 30.9 |
| Radish, Winter | 32 | 95-100 | 2-4 mon. | -- |
| Rutabaga | 32 | 98-100 | 4-6 mon. | 30.0 |
| Squash, Winter | 50* | 50-70 | Varies | 30.5 |
| Sweet Potato | 55-60* | 85-90 | 4-7 mon. | 29.7 |
| Turnip | 32 | 95 | 4-5 mon. | 30.1 |

*Require curing before long-term storage

Potato: 50-60 & 98% RH 10-14 days

Winter Squash: 80-90 for 3-5 days w ventilation

Sweet Potato: 85 & 90-95% RH for 4-7 days

Adapted from Knott's Handbook for Vegetable Growers

**Great free publication: www.ba.ars.usda.gov/hb66/contents.html**

## From Field to Storage: High Quality Carrots

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In response to increasing demand for local vegetables through the winter months, growers are expanding their production of root vegetables for winter storage. Carrots are a widely grown storage crop with a strong market demand. Under ideal conditions carrots can be stored for 6 months, but in sub-optimum storage conditions they suffer from water loss, change in taste and texture, diseases, and sprouting. Growers in New England are using a wide range of harvest and post-harvest practices for carrots. Available storage conditions may be less than ideal, and varieties may differ in their response to different conditions. At the UMass Vegetable Program from 2010-2013, we explored some of the factors that quality in storage, including variety, harvest date, postharvest washing, and storage conditions. See *Carrots for Winter Sales: Varieties, Planting Dates and Post-Harvest Care* by Amanda Brown (Root Crops Session) for details on varieties and dates of harvest. In this article we will cover what we learned about how those factors played out in storage.

**2010-2011 Varieties in Storage.**
Methods. Six storage carrot varieties (Bastia, Berlanda, Bolero, Canada, Carson, Sugarsnax) were planted on June 28, 2010 and harvested on 4 dates (Sept. 29, Oct. 12, Oct.27, Nov. 10). At harvest, marketable carrots (U.S. No.1 & U.S. No.2) were washed by hand in buckets (with 1/4 cup per 4 gallons) and placed in perforated plastic bags in a cold storage room with temperature at 32-37 degrees F (avg 35F) and RH>95%. Monthly from December through March, we pulled carrots to measure ºBrix and water loss. For Brix, slices were frozen, then thawed to release juice. Results. *Water loss* occurred at low levels throughout the storage period, was consistent across varieties, and averaged 5-11% between harvest and March 1. *Brix readings* increased from December through February, and declined sharply in March. While there was variation in Brix readings among varieties, this pattern was consistent.

**2012-2013 Storage Case Studies**. We used Bolero carrots grown at the UMass Research Farm as a model crop to examine how conditions at four on-farm storages affected carrot quality through the winter months. While these case studies cannot fully address the question of trade-offs between quality and cost, they do offer insight into how different storages affect quality and marketability.
Methods. We seeded Bolero carrots on July 11, harvested on November 13/14, and placed in the storage facilities immediately after harvest. Carrots were stored unwashed or were barrel-washed pre-storage, to match the conditions of each farm's storage. If carrots were stored loose at a farm, we placed ours in mesh bags (10/bag, 4 replicates) to distinguish them from other carrots and placed them with the farm carrots. If carrots were stored in perforated plastic at a farm, we placed ours 10 to a bag in perforated plastic bags. Temperature was monitored with Hobo dataloggers. We removed one set of bags from the storage each month to sample water loss, Brix score, rubberiness, rot, and other measures of carrot quality. We also brought carrots

from on-farm storages to the Amherst winter farmer's market in January, February, and March and asked attendees to sample slices of each carrot and rate the carrots based on texture, taste, and appearance. Carrots were rated on a 1-5 scale, with 1 being poor and 5 being excellent.

Farm Storage Facilities

Farm A: 1300 sq ft underground root cellar, cement walls & spray foam ceiling insulation. Active cooling with ambient air is provided by an 8" pipe with fan, and passive cooling through other openings. Outdoor T remained high through December, and this storage reflected that: T stayed in low 40's until mid deck., between 35 and 40 ºF until Jan. 22, 35-38 ºF until the end of Feb, and below 40F until March 27. Carrots storage: unwashed in woven plastic grain sacks. Humidity: respiration of stored vegetables, supplemented by wetting the floor.

Farm B: 8' x 8' x 10' tall walk-in cooler, with a compressor, condenser, and fans, standard refrigeration panels and foam-board in the floor. Storage temperature is set at 38F year-round, and our dataloggers showed T was consistent at 36-38 F from harvest through April, dropping as low as 33 during a cold spell in early January. Humidity: water from wet greens soaks into the plywood floor and keeps the storage quite humid. Carrot storage: barrel-washed, stored in 25 lb perforated bags. The farm has been able to store carrots successfully into April or May.

Farm C: underground basement of a large barn, 21' x 47 ' x ~7' tall, insulated with 4+ inches of spray foam insulation inside the walls and ceiling, as well as aboveground walk-in cold storages. All are heated and cooled by a geothermal system and cold air from outside. Dataloggers showed T dropped steadily from 41F 11/15 to 36 by 12/25 and stayed between 34 and 36 through the first week of April. Carrot storage: unwashed in large macro 34 vented bins on pallets. Humidity: carrots are misted, and shrink-wrapped or simply covered on top with a layer of plastic.

Farm D: a 320 sq ft concrete storage built for high RH, low T storage; ceiling is insulated with foam, sides are flanked by two other coolers, and the back side is insulated by the earth. The cooler is a low velocity unit cooler run on hard-wired electricity. An automated spray system kicks in when the humidity falls too low. Storage T ranged from 31 to 36 ºF. Carrot storage: washed at harvest, stored in large bins within 25 lb capacity vented plastic bags. We tested both perforated and mesh bags, placed on top of or nestled in pallets containing farm carrots that were bagged in perforated plastic.

Results. *Water loss* over three months was 13% at Farm A and in carrots in mesh bags at Farm D, compared to less than 2% at Farms B,C, and Farm D for carrots in perforated plastic. The water loss in mesh in the cold, high RH environment for Farm D was unexpected. *Rubberiness* – Carrots that experienced water loss also became 'rubbery'. Marketability was not affected at low levels of rubberiness, but by February, 80% of carrots in mesh bags at Farm D were rated as unmarketable. We found *Brix scores* to be higher in the carrots that experienced greater water loss, likely due to the fact that loss of water meant sugars were concentrated in the water that remained. In *taste tests*, we saw changes over the course of the storage trial period. In January, after two months of storage, the carrots stored under the closest to ideal conditions – at Farm C and at Farm D in plastic – were rated higher in appearance, flavor, texture and preference compared to carrots stored in mesh at Farm D and carrots from the root cellar at Farm A. In February, results were similar except that we found no difference in taste and texture ratings;

anecdotally, some people appreciated the crunch and crispness of the carrots that had been stored under ideal conditions, while others noticed the sweetness of the carrots that had experienced greater water loss. By March, carrots from the root cellar (Farm A) were rated highest in flavor and texture – apparently the higher sugar content was especially noticeable at this point, compared to crispier carrots that were less sweet.

**To Wash or Not to Wash.** One long-standing debate is on the merits of washing carrots before placing them into storage. The decision to wash carrots before storage, or immediately before sale during the winter months, is usually based on a farm's washing facilities (heated or not) and available labor. In the 2012-13 season, we stored Bolero carrots from the UMass Research Farm (seeded July 10 & harvested Nov. 5) under three postharvest treatments: barrel-washed, hand-washed (scrubbed in a bucket by hand), and unwashed (stored unwashed, and washed just before evaluation). For each treatment, carrots were placed in perforated plastic bags, and stored at 32-34 degrees, 95% RH. For each month in storage, we pulled out designated bags to evaluate rot, staining and lenticel dirt, top sprouting, hair sprouting, water loss, flavor, and crunch, and Brix readings.

Results. *Rot* – There was no effect of treatment on root rot in our 2012-2013 trial – washing did not lead to higher levels of rot. *Staining* – Some staining was apparent in unwashed treatments this year, manifesting as a slight brownish cast on some carrots. However, overall, staining was quite low, and difficult to distinguish from the off-color whitish cast that occurs in older carrots, no matter how they were stored. *Hair sprouting* – In the April sample only, we found higher rates (20-40%) of hair sprouting (white hairs growing along the carrot) in both washed treatments, compared to 2.5% in unwashed. Hair sprouting indicates that the carrot is becoming biologically active, which will render it unfit to eat. *Other variables* – We found no effect of washing treatment on water loss, flavor, lenticel dirt, or top sprouting of carrots.

**Discussion and Conclusions.** Storing carrots under ideal conditions does a great job of protecting carrots from water loss, and maintaining crunch. We found in our case studies that a simple solution, like a walk-in cooler (Farm B), minimized water loss as well as a specially designed facility (Farms C and D), as long as packaging of the carrots is adequate. Reliance on ambient air for cooling may not achieve the desired low temperatures as quickly as needed, which may increase water loss because the warmer air requires more water to achieve the same relative humidity. Marketability was maintained in all four on-farm storages, even under less than ideal conditions. A limited amount water loss appears to be tolerable and in fact lead to sweeter carrots over time. When water loss was low (5-11% in 2010-11 storage trial, and <2% in 2012-2013 study), we observed a tendency for carrots to decline in sweetness after February.

Carrots can be successfully stored unwashed without significant staining occurring, at least for the Hadley silt loam found in Deerfield MA. This may differ among soil types; in a 2009 washing trial at Jerrico Settlers Farm in Jerrico, VT found increased staining in unwashed carrots. Like Jerrico Settlers Farm, we found that carrots can be stored washed without rot, though there was a slight increase in rot and in 'hairiness' late in the season. Washing by hand or barrel worked equally well. The success of either approach to washing will vary with soil type, storage conditions and storage duration, but it appears that either can work well.

**Using Cover Crops in High Tunnels**

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Happy Town Farm is a small, diversified organic farm where we grow 4 acres of vegetables and flowers, raise a variety of animals and poultry, and make maple syrup. As part of our growing operation we have four high tunnels. One of the high tunnels is dedicated to flowers and the other three are used to grow vegetables. Two of the vegetable houses are 21’ by 96’ and the other one is 17’ by 96’. We try to market crops from the high tunnels nine months of the year. As an organic farmer we use crop rotation, compost, green manures and cover crops to build and maintain the fertility of the soil, both in the fields and in the high tunnels. The vegetables are grouped in families and are rotated through the houses. The first year of the rotation is tomatoes, the second is cucumbers and basil, and the third year is salad greens and lettuce. After the tomatoes are cleaned out, usually the last week of October or the first week of November, we plant winter rye or hairy vetch and winter rye. Also, in the house that will be in greens the next summer, half of the house is planted to greens in the late fall and the other half of the house to winter rye. The green manure crop grows until late April by which time the rye is three to four feet tall. It is then cut with a weed wacker and incorporated with a Troybilt rototiller. In two weeks we spread compost, lay plastic and transplant seedlings.

Over the years, we have been very pleased with the health and vigor of the crops grown in our high tunnels following the rye cover crops.

## Soil Management and Soil Quality in High Tunnel Production Systems

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Growers have indicated that changes in soil quality under production in high tunnels is an important problem, but these have not yet been quantified or critically assessed in the central Great Plains of the U.S.A. We conducted surveys of grower perceptions of soil quality in their tunnels (n=81) and compared selected soil quality indicators (salinity and particulate organic matter carbon) under high tunnels of varying ages with those of adjacent fields at sites in Kansas, Missouri, Nebraska and Iowa in the U.S.A.

Soil was collected from high tunnels and adjacent fields on farms in Kansas, Missouri, Nebraska, and Iowa in the autumn of 2006. Soil collection was focused on high tunnels that had been in place at least three years. Soil was collected adjacent to the high tunnel for quality comparison. Management of the adjacent fields varied. Locations where soil under the high tunnel was not that of the adjacent field (e.g., creek bottom soil had been brought into the high tunnel) were not included in the data set. Soil samples representing a high tunnel or field were a combination of at least five random collections within crop rows. Soil was collected from the surface 5-cm for salinity analysis. Soil particulate organic matter carbon, total carbon, and salinity were determined in soil collected to the 15-cm depth with a soil probe.

Fourteen percent of growers surveyed considered soil quality to be a problem in their high tunnels, and there were significant correlations between grower perceptions of soil quality problems and reported observations of clod formation and surface crusting, and to a lesser extent surface mineral deposition. Grower perception of soil quality and grower observation of soil characteristics were not related to high tunnel age.

Soil surface salinity was elevated in some high tunnels compared to adjacent fields, but was not related to time under the high tunnel (Figure 1.). In the soil upper 5-cm, salinity in fields did not exceed 2 $dS \cdot m^{-1}$, and was less than 2 $dS \cdot m^{-1}$ under 74% of high tunnels, and less than 4 $dS \cdot m^{-1}$ in 97% of high tunnels.

Soil organic matter (SOM) is a commonly used biological indicator of soil quality. Organic matter influences soil structure, nutrient storage, water holding capacity, biological activity, tilth, water and air infiltration. Particulate organic matter (POM) is labile organic matter of size fraction 53 micrometers to 2 mm, and it has the advantage as an indicator of soil quality of faster response to environmental change than SOM. Changes in POM can be used to predict trends in SOM. Particulate organic matter has been correlated to microbial biomass, C and N mineralization, and soil aggregate formation and stability, demonstrating that increased POM indicates improved soil quality. Evaluation of the portion of the soil carbon in the particulate organic matter size fraction can be used for comparison of locations or for comparison of changes over time.

Many growers give high tunnels priority when applying organic soil amendments, so that much of the organic matter in high tunnels may be fresher or less decomposed. In the survey 85% of growers reported the use of organic amendments in their high tunnels. This was also evidenced in analysis of total soil carbon in that 70% of high tunnels were found to have higher total C than their adjacent field, with 16% having double the amount of C. Total carbon under high tunnels ranged from 12 to 125 g $C \cdot kg^{-1}$ soil, and in adjacent fields from 11 to 96 g $C \cdot kg^{-1}$ soil. Soil carbon does not typically exceed 40 g $C \cdot kg^{-1}$ soil (4% of soil mass) in a Mollisol or Alfisol. Total soil carbon was higher than this in 25 % of the high tunnels, but only in 6% of the fields sampled.

Particulate organic matter carbon as a fraction of total carbon ranged from 0.11 to 0.67 g POM $C \cdot g^{-1}$ TC under high tunnels (Figure 2). In the fields, the POM $TC^{-1}$ was 0.10 to 0.89 g POM $C \cdot g^{-1}$ TC. In other studies, POM was observed to make up 10% of total soil C (0.10 g POM $C \cdot g^{-1}$ TC) in long-term arable soil and 0.4 g POM $C \cdot g^{-1}$ TC under grassland. Particulate organic matter carbon exceeded 0.4 g POM $C \cdot g^{-1}$ TC in 26% of high tunnels and 9% of the fields adjacent to high tunnels. It exceeded 0.25 g POM $C \cdot g^{-1}$ TC in 78% of high tunnels compared to 48% of adjacent fields. High tunnel POM $TC^{-1}$ tended to exceed that in adjacent fields, possibly indicating better soil quality under high tunnels. Seventy-three percent of high tunnels had POM $TC^{-1}$ in excess of the adjacent field, indicating that soil organic matter under high tunnels tends to be less decomposed than in open fields.

The effect of high tunnel age on the quality of the soil was one objective of this study. The ages of high tunnels sampled on farms ranged from one to fifteen years. The median high tunnel age was five years. Grower perception of soil quality did not differ with age of high tunnel. Growers with tunnels in situ for two to 15 years reported good soil quality (n=41). Growers who reported soil quality problems had tunnels ranging in age from three to eleven years. Observations of negative soil attributes (surface clod, crust formation, and hardpan presence) were not related to time under a high tunnel.

Measured indicators of soil quality were also not correlated to the age of high tunnels. Salinity was not significantly correlated to high tunnel age. The POM $TC^{-1}$ in high tunnels was also poorly correlated to tunnel age. The portion of soil C made up by the POM fraction differed between high tunnel and adjacent field, but this difference was not because of the length of time a high tunnel covered the soil, as indicated by the lack of correlation between POM HT:Field and tunnel age

Acknowledgements: This summary includes excerpts from the publication "Knewtson, S.J.B., R. Janke, M.B. Kirkham, K.A. Williams, and E.E. Carey. 2010. Trends in soil quality under high tunnels. HortScience 45:1534-1538."

Figure 1. Salinity in the surface upper 5-cm at (a) sixty-three field locations adjacent to high tunnels and (b) ninety-three high tunnels in the central Great Plains, arranged from newest to oldest from left to right, and (c) salinity in the soil upper 15-cm in the high tunnels with salinity exceeding 2 $dS \cdot m^{-1}$ in the upper 5-cm.

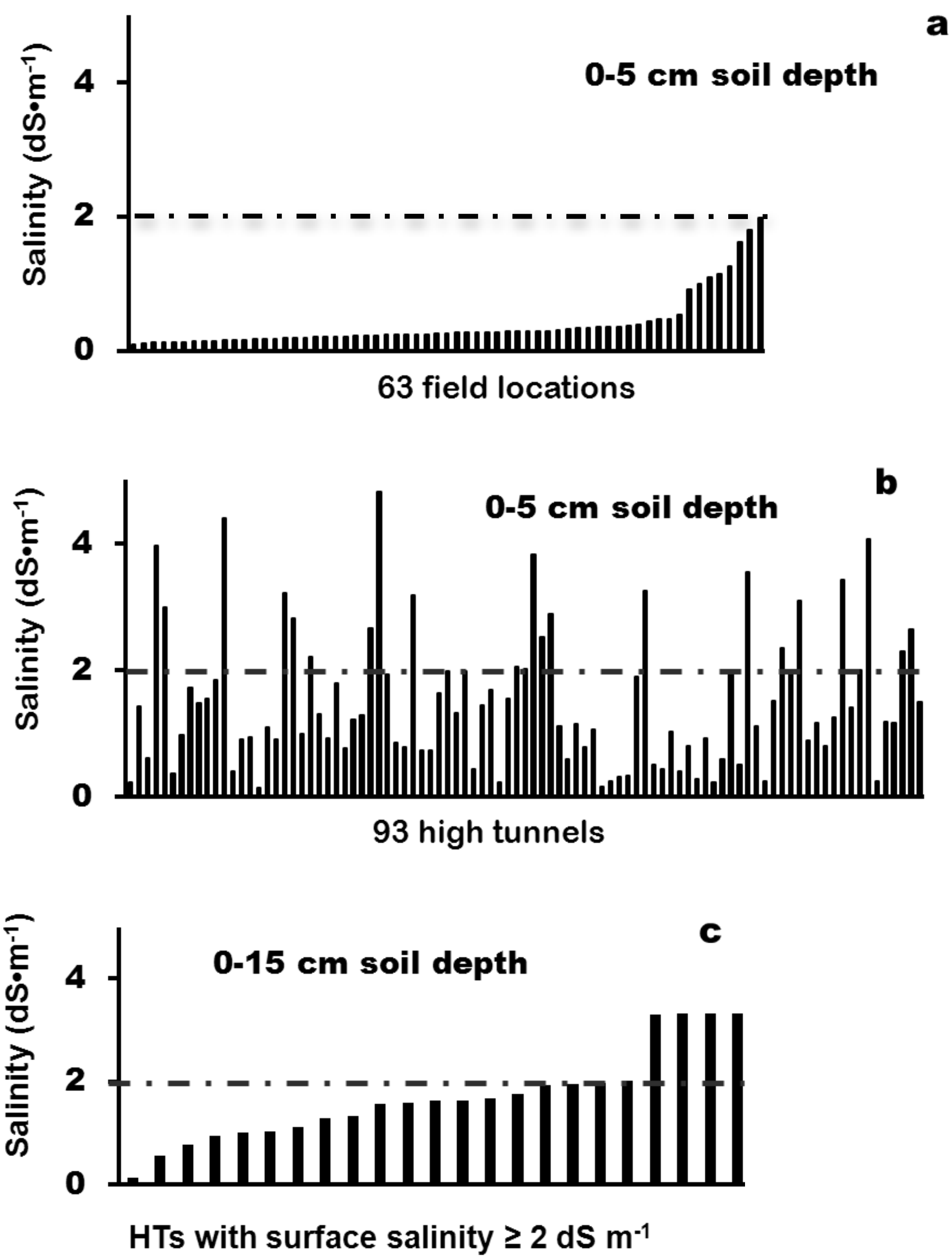
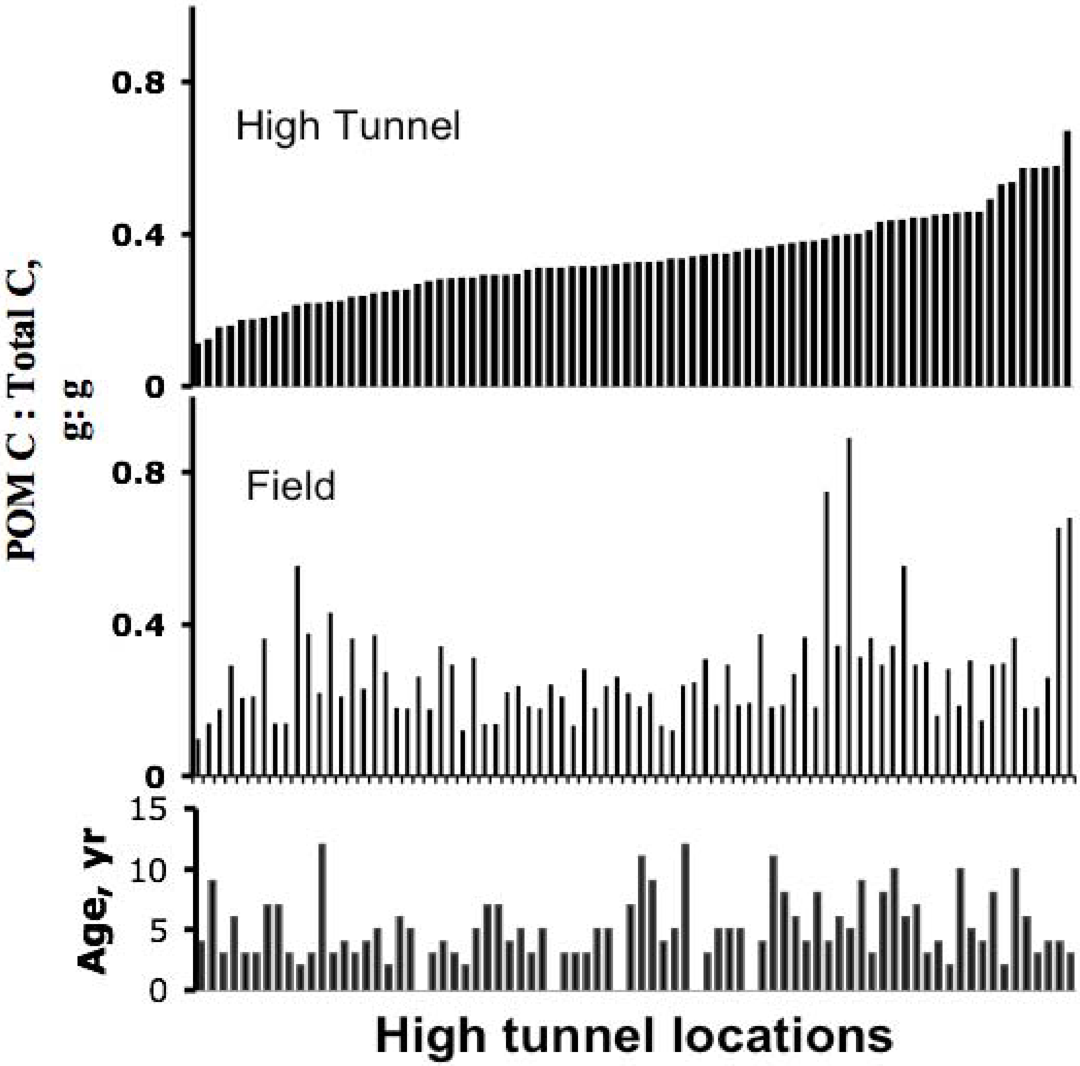


Figure 2. Particulate organic matter carbon as a fraction of total soil carbon in high tunnel and field, and the age of the high tunnel with matching x-axes indicating 93 high tunnels sampled in 2006.



## Soil Testing Options for High Tunnel Production

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High tunnel production systems offer several obvious advantages over open-field production. They also present unique nutrient management challenges. Primary advantages include greater control of nutrients and water, enhanced heat gain, additional growing degree days, and extension of the growing season both earlier and later in the year. With the advent of holding and harvesting late-planted crops through the winter (Coleman, 1999), many houses are being double or even triple-cropped each year. With no natural precipitation, all water must be supplied by irrigation – usually drip irrigation. Control over water inputs allows for better control of foliar diseases on susceptible crops such as tomatoes. Higher soil temperatures result in faster N and P mineralization rates from both chemical and non-chemical amendments.

There are also potential, and sometimes unanticipated, disadvantages to this system. Very high heat gain requires ventilation to avoid overheating. Higher temperatures in an enclosed environment – often in monoculture – can worsen insect pest problems. Greater biomass production creates greater nutrient demand from the soil. Soil nutrient levels that may have been adequate or only marginally deficient in an open-field system may result in a major deficiency in a high tunnel system.

One of the most common problems in a continuously covered high tunnel system is the buildup of nutrient salts over time. With no natural rainfall to flush excess salts and irrigation supplied only to satisfy crop requirement, yearly net movement of water is upward through the soil profile rather than downward. Evaporation from the soil surface plus transpiration demand by plants wicks water and dissolved nutrient salts to the surface where they can accumulate to levels sufficient to cause damage to crop plants. In this aspect, high tunnel soil management is very similar to irrigated desert production in the west and southwest. Many growers used to open-field production systems fail to realize this potential problem or take steps to remediate, such as uncovering to natural rainfall or otherwise flushing accumulated salts from the soil with high volumes of water. With minimal leaching or denitrification potential, nitrate carryover from one crop cycle to the next is another major difference compared to open-field production systems.

As requests for soil testing services for high tunnels increased at the University of Maine, it became apparent that routine field soil testing was inadequate to address many of the potential problems inherent in these production systems. Since high tunnel growers employ a wide range of soil amendments and management intensities, it became necessary to offer a range of testing options.

### Appropriate Testing Systems

For new high tunnels, transitioning from an open-field to a covered production system, the most appropriate testing option is still a routine field soil test. Since greater productivity and greater nutrient demand is anticipated, all soil levels should be adjusted to the upper end of the optimum range for pH, organic matter, and all major and micronutrients according to existing soil fertility guidelines for open-field production. Even marginal nutrient levels should be amended to avoid potential deficiencies under high biomass production demands.

After the first cropping year, the potential for nutrient salt buildup and nitrate carryover should be addressed. Our first enhanced testing package called the Basic High Tunnel package is a traditional field soil test plus total water-soluble salts (by electrical conductivity or EC) plus a direct measurement of available nitrogen ($NO_3$-N and $NH_4$-N). This package has worked very well for the majority of our high tunnel growers. As with any traditional soil test, it monitors the season-long reserves of available nutrients. It also alerts the grower to potential salt buildup problems in a covered system. Since there is little or no loss of available nitrogen to factors other than plant uptake, ongoing nitrogen management can be adjusted based on residual nitrate levels in the soil.

As the high tunnel industry matured there was an increased incidence of uniformly high or above optimum nutrient levels, when comparing to field soil testing guidelines. With anecdotal evidence of enhanced yields at soil test levels well above established guidelines, it became apparent that the existing testing system was not fully addressing nutrient demands in some highly productive houses. All field soil test interpretations are based on the capacity of the soil to retain and supply nutrients over one or more full seasons. Since many high tunnel soils were exhibiting levels in excess of this inherent capacity, it made sense to start monitoring "free-salt" nutrient levels – those in excess of the soil's retention capacity. This is done using the Saturated Media Extraction (SME) method.

For decades the SME has been the routine method used for greenhouse bench crops grown in soil-less mixes (Warnke, 1998) and also in irrigated soils in arid production systems in the west and southwest (Western States Program, 1998). This became our second testing system for high tunnels, called the Long-Term High Tunnel package. It was developed in collaboration with Vern Grubinger at the University of Vermont, who has been a strong advocate of the SME test for Vermont high tunnel systems.

The Long-Term package is most appropriate for those houses that have been continuously covered and/or aggressively amended, have a relatively high EC level, and very high reserve nutrient levels. Nutrients are monitored and managed at the water-soluble level using the SME system. The SME monitors the pool of immediately available nutrients (nutrient intensity), rather than available nutrients held in reserve (nutrient quantity) measured in a typical field soil test. Organic matter level is also monitored to address soil moisture retention capacity. Interpretation and recommendation guidelines are based on the work of Wittwer and Honma (1979) (fig. 1 & 2). Recommendation guidelines were modified from the original chemical sources to non-chemical sources required by organic production standards (Grubinger, 2012).

Figure 1.

## Optimum SME Ranges

| GH Tomato/Cuke (Wittwer & Honma) | | Current High Tunnel (ME & VT) | |
|---|---|---|---|
| pH | 5.8 – 6.8 | pH | 6.0 – 7.0 |
| $NO_3$-N | 125 – 200 ppm | $NO_3$-N | 100 – 200 ppm |
| P | 8 – 13 ppm | P | 1 – 5 ppm |
| K | 175 – 275 ppm | K | 150 – 275 ppm |
| Ca | > 250 ppm | Ca | > 250 ppm |
| Mg | > 60 ppm | Mg | > 60 ppm |
| EC | 1.5 – 3.0 mmhos | EC | 2.0 – 4.0 mmhos |

Figure 2.

## Estimated fertilizer rates to increase SME nutrient levels

| Pounds/1,000 sq. ft needed to raise N approximately 10 ppm | |
|---|---|
| Blood meal 12-0-0 | 4.2 |
| Soybean meal 7-1-2 | 7.2 |
| Alfalfa meal 2.5-2-2 | 20.2 |

| Pounds/1,000 sq. ft needed to raise P approximately 2 ppm | |
|---|---|
| Bone char 0-16-0 | 25 |
| Rock phosphate 0-3-0 | 133 |

| Pounds/1,000 sq. ft needed to raise K approximately 20 ppm | |
|---|---|
| Sul-Po-Mag 0-0-22-11Mg | 2.6 |
| Potassium sulfate 0-0-52 | 1.1 |
| Alfalfa meal 2.5-2-2 | 28.6 |

| Pounds/1,000 sq. ft needed to raise Ca approximately 25 ppm | |
|---|---|
| Calcium sulfate (gypsum) | 7.5 |
| Calcitic lime (low Mag) | 7.5 |
| Dolomitic lime (hi Mag) | 5.3 |

Adapted from Wittwer & Honma

The SME test package has worked well for highly-amended systems with high demand crops, such as tomato. In either testing system, very high soluble salt levels (> 4 dS/m) must still be addressed to avoid desiccation damage to crop plants. Salt levels can be reduced, either by uncovering to natural rainfall, flushing with several inches of water, or by physical dilution with peat moss or additional field soil.

**Method Comparison and Calibration**

The two high tunnel test methods differ fundamentally in at least two ways. Each accesses different pools of available nutrients (quantity vs intensity). There is also a difference in the reporting basis. A conventional field soil test reports available quantity in the dry soil as either parts per million (ppm) or pounds per acre. The SME is reported on an extract basis as mg/liter (ppm in the extract). Because of these differences, there is not a consistent relationship between numerical results for most nutrients. There may also be significant differences between the "Low-Medium-Optimum" interpretation levels. The only consistent relationship is that a Low quantity test will invariably cause a Low intensity reading. However, depending on the frequency of flushing salts, an Optimum or Above Optimum quantity test level will not necessarily correspond to an Optimum or High intensity reading. Therefore, each testing package requires its own interpretation and recommendation system and should be considered separately.

A calibration project was undertaken in 2010 in VT using both soil testing systems run at the University of Maine. Both soil testing systems identified potassium as potentially limiting. Three rates of N and K were applied in a factorial RCB design in an existing tomato house. There was a definite trend in yield response to potassium, but due to a disease-shortened season and high background variability, it was not statistically significant.

Even with a shortened season, fruit yields alone resulted in equivalent nutrient removal on a per acre basis of 200 lb N, 80 lb P and 500 lb K – demonstrating the very high nutrient demand on high tunnel soils. Efforts are ongoing to verify and modify existing guidelines for both Quantity and Intensity testing systems for these very high nutrient demand high tunnel systems.

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**Proper Air Blast Sprayer Calibration**

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As stated on the pesticide label – the sprayer needs to be calibrated before you spray!

Proper calibration of air blast sprayer equipment is the only way to ensure spray applications are effective, efficient and economical. Poor spray coverage is the primary cause of reduced spray product performance. Regular care and maintenance will ensure the sprayer is residue-free and serviceable when needed. A sprayer should never be operated without first checking the calibration for the following reasons:

1. To determine the precise rate of material applied per acre.
2. To ensure each nozzle tip is operating at the manufacturer's specification.
3. To compensate for equipment changes, crop staging and environmental conditions.

Ideally sprayers should be calibrated at the beginning of the season, whenever nozzles are changed, or when changing the nozzle set up based on the crop and desired coverage. The challenge with air blast sprayer calibration is accurate and efficiently collecting and comparing the output from the individual nozzles. As a result, growers most often calibrate by determining how much spray material they had in the tank when starting the application and subtracting how much remained in the tank at the completion of the application and then dividing that amount by the estimated number of acres covered during the application. This method indicates the approximate the gallons per acre for the application. However, it does not give an accurate picture of where the actual material was applied. For example, that method may indicate that fifty gallons per acre was applied but a leak in a hose or somewhere else on the equipment may mean that part of that "application" actually ended up on the ground. If one or more of the nozzles are compromised or worn, then fifty gallons per acre may not be accurately applied to the crops, and uneven application means uneven control of the pest population, which can lead to damage to part of the crop.

**<u>Calibration Factors Affecting Application Rate</u>**

- <u>Ground Speed</u>
  A uniform ground speed is necessary to maintain even spray application. The spray application per acre varies inversely with the ground speed of the sprayer. If the ground speed is doubled the application rate is cut in half and as the ground speed is reduced to half, the spray application is doubled. Rate controllers can only compensate for this within certain limits and can sometimes have a negative impact on spray quality.
- <u>Nozzle Flow Rate</u>
  The flow rate through the nozzle varies with the tip size, the pressure applied, and the condition of the tip.

## Pre Air Blast Sprayer Calibration Instructions

Prior to calibrating an air blast sprayer, please complete the following tasks:

1. Triple rinse tank and piping. Take special care to flush manifolds and nozzles.
2. Be careful if using pressure wash sprayers. Some say this forces water into sealed parts like bearings. You can use push brooms and hoses to scrub them off. Pay special attention to cleaning both sides of nozzles and around pump and filters.
3. Clean nozzles and record orifice and whirl disc sizes.
4. Flush out line to pressure gauge.
5. Clean filters, including tank filters, suction filters, final filters, and every screen behind nozzles.
6. Make sure all valves, diaphragms, and O-rings are in good condition and working properly.
7. Check tire pressures on both sprayer and tractor.
8. Make sure tachometer is working on tractor.
9. Fill sprayer ½ full with clean water.
10. Please have any operators or mechanics that work with the sprayer/tractor combination on hand for the sprayer calibration.
11. Have sprayer operators manual on hand.

## Maintenance of the Sprayer

The following practices will prolong the life of the sprayer:

1. Remove the nozzles and strainers; flush with clean water regularly.
2. Do not use any metal object when cleaning sprayer tips. Use a soft brush or try a can of compressed air (for cleaning keyboards).
3. Never apply corrosive fertilizer solutions through an air blast sprayer.
4. Remove and clean strainers daily or when products change on sequential applications, whichever comes first.

Nozzle wear occurs most rapidly when wettable powders, flowables, or dispersible granules are applied, especially at high nozzle pressures. Under these situations, the tips and cores on the sprayer should be manufactured from hard, wear resistant materials. The abrasion resistant nozzle components cost more initially, but in the long term are quite cost effective.

## Calibration Notes

Recording your sprayer calibration calculations for future use is important. By having a record, you can compare your sprayer calibration calculations from calibration to calibration. This information can be useful the next time you check the calibration. This recordkeeping is also due-diligence and is important to have on hand if ever a question arises about product residue, pesticide drift, or any other spray complaint.

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# Air-Blast Sprayer Calibration Worksheet

***Retain the following information for your records:***

Date _________________.

Farm_________________________ Operator ____________________ Phone ________________.

Address_______________________ Town __________________ State ______ Zipcode _________.

Tractor _______________________ Sprayer________________

Tractor Gear __________________ Tank_____________gallons

Tractor RPM___________________ Pump Pressure________PSI

Measured Distance_______ feet

Time in seconds (down) __________

Time in seconds (back) __________

Average Time in seconds _________ ***MPH*** *= Miles per Hour*

Miles per Hour = $\frac{\text{Distance in Feet x 60}}{\text{Time in Seconds x 88}}$ = $\frac{(\_\_\_\_\_\_\text{ Feet) x 60}}{(\_\_\_\_\_\_\text{ Seconds) X 88}}$ = _________ = _________ MPH

*For Orchards:*

Block (#____________) Tree Height _______ ft. Tree Width _______ ft. Row Width __________ ft.

*For Vegetable or Other Crops Sprayed:*

Crop:_________________________

Block (#____________) Spray Swath Width ___________ft

Linear Feet of Row per Acre = $\frac{43{,}560}{\text{Row Width Or Spray Swath Width}}$ = $\frac{43{,}560}{(\quad\quad)}$ = (_____) Feet per Acre

Speed in Feet per Minute = MPH **X** 88 = (_____) MPH **X** 88 = (_______) Feet per Minute

| Nozzle Output for Air-Blast Sprayer - To determine the left versus right side, look at the sprayer from behind | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nozzle Output - Left | | | | | Nozzle Output - Right | | | | |
| Nozzle # | Tip Size # | Disc Core # | Fluid Ounces Per Minute | Gallons Per Minute | Nozzle # | Tip Size # | Disc Core # | Fluid Ounces Per Minute | Gallons Per Minute |
| L-10 | | | | | R-10 | | | | |
| L-09 | | | | | R-09 | | | | |
| L-08 | | | | | R-08 | | | | |
| L-07 | | | | | R-07 | | | | |
| L-06 | | | | | R-06 | | | | |
| L-05 | | | | | R-05 | | | | |
| L-04 | | | | | R-04 | | | | |
| L-03 | | | | | R-03 | | | | |
| L-02 | | | | | R-02 | | | | |
| L-01 | | | | | R-01 | | | | |
| Total Left Side Manifold Output in GPM | | | | | Total Right Side Manifold Output in GPM | | | | |
| Total Output for Sprayer in GPM | | | | | | | | | |

***GPM*** *= Gallons per Minutes* ***GPA*** *= Gallons per Acre* ***MPA*** *= Minutes per Acre or Minutes/Acre*

All Nozzles Output = (_______) GPM

Block (#_______) Minutes/Acre = Linear Feet Row per Acre / Feet per Minute = (__________) / (          ) = (________) Minutes/Acre

Output - Gallons Per Acre = GPM **X** MPA = (_______) GPM **X** (_______) MPA = (_______)GPA

**NOTES:**

*George Hamilton, Extension Educator, Agricultural Resources, Hillsborough County* *July 15, 2013*

**Selecting Fungicides to Minimize Resistance Development and Avoid Phytotoxicity and Fruit Finish Problems**

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Devising seasonal disease-control programs for apples is increasingly complicated because of concerns about fungicide resistance, because some tank mixtures can burn leaves or fruit, and because fungicide mixtures are often needed to cover the full spectrum of apple diseases.

Selecting fungicides for resistance management: All fungicides are classified by the Fungicide Resistance Action Committee (FRAC: see http://www.frac.info/ ) into groups wherein products with similar modes of action have the same FRAC group number (Table 1). All of the newer fungicides are "at risk" for development of resistance. Managing fungicides to delay resistance requires an integrated program evolving from the following considerations:

1. Keep inoculum levels as low as possible. For apple scab, this involves using fall or spring urea sprays and/or leaf chopping to reduce ascospore numbers in blocks that had scab last year, and using contact fungicides (mancozeb, Polyram, Captan) in combinations with all at-risk fungicides. Contact fungicides kill spores before they germinate whereas most at-risk fungicides kill fungi only after spore germination is initiated. Therefore, when the contact fungicides are applied in combinations with the at-risk fungicides, the contact fungicides act first by killing spores they contact, thereby reducing the amount of inoculum that must be managed by the at-risk fungicide.
2. Use different classes of fungicides (products with different FRAC numbers, Table 1) in rotations during the season. Labels for many of the newer products indicate that after the product has been applied twice it cannot be used again until after a different chemistry group has been applied at least one time. If a program that was historically effective on your farm begins to break down, shift to a different program immediately so as to avoid both the economic losses and the inoculum buildup that occur when fungicide resistant populations are ignored as they first begin to appear.
3. For any given disease, reserve the most effective at-risk fungicide for the period of peak risk for the disease being targeted. The peak risk period for primary scab is usually pink through petal fall whereas the peak risk period for mildew is petal fall through second cover. (Sprays before the peak risk period are also important, but the greatest amount of primary inoculum usually becomes available during the peak periods indicated.) In selecting the most effective fungicide, one must consider both the intrinsic activity of the fungicides and any suspected or known shifts toward resistance in the pathogen population for the specific orchard in question.
4. Use full label rates of the at-risk fungicides, and avoid extended spray intervals. When an infection period occurs during the latter part of an extended spray interval, the pathogen will encounter a much-reduced concentration of the fungicides, thereby increasing the selection pressure for resistance development. Remember that resistance management strategies for

plant pathogens is more akin to strategies used in human medicine than it is to strategies used by entomologists. Using reduced rates of at-risk fungicides is like stopping an antibiotic regimen prescribed by your doctor as soon as you feel a bit better. In both plant pathology and human medicine, using the full dose is a critical for resistance management.

5. Use programs that will simultaneously reduce resistance risks for both apple scab and for powdery mildew. If fungicides selected to control scab at tight cluster or pink do not have activity against mildew (e.g., mancozeb plus Syllit, Scala, or Vangard), then add sulfur to the mix so as to prevent early infections of mildew that, left uncontrolled, would result in more inoculum at petal fall. If sulfur cannot be used because of pre-bloom oil sprays, then the pre-bloom scab program should be changed to include some other mildewcide.
6. Three-way mixtures of fungicides in the same tank are becoming essential for managing multiple pathogens (e.g., scab, mildew, black rot) while simultaneously contending with resistance issues even though this approach seems inconsistent with previous IPM strategies. An effective three-way mixture applied at critical junctures in the primary scab season can eliminate scab control failures that might otherwise necessitate summer-long applications of high rates of Captan. Effectively managing primary scab and mildew also eliminates the selection pressure that occurs if at-risk fungicides are used in June to arrest these pathogens after lesions appear on leaves. Thus, three-way mixtures of fungicides can make sense both economically and as a long-range IPM strategy.

**Avoiding phytotoxicity problems:** Perfect disease control is of little value if fruit are marred due to phytotoxicity from one of the products applied to manage pests. The most common contributors to phytotoxicity in apples are copper, sulfur, and Captan, but other products may also cause occasional problems. For example, I recently became aware that Topguard applied to drip under cool conditions may cause leaf spotting and/or leaf edge burn, especially on Braeburn. Repeated applications of full rates of phosphite fungicides can result in development of narrow strap-shaped terminal leaves that look somewhat like glyphosate injury.

Copper that is applied or redistributed onto flower parts or fruit after tight cluster will frequently cause fruit russetting. Copper applied in summer sprays can cause blackened lenticels. Risks from copper injury can be reduced by applying copper (for fire blight suppression) only up until green tip. Organic farmers or others wishing to use copper to control fire blight during bloom should use one of the low rate copper products (Table 1) and apply it with low volumes of water to dry foliage under rapid-drying conditions.

Neither sulfur nor Captan will cause leaf or fruit spotting if they are applied alone and well separated from applications of oil or urea (except that sulfur applied in hot weather can burn fruit). Urea, oil, solvents in pesticides formulated as ECs, and spray adjuvants that enhance leaf penetration will increase the probability of leaf and fruit injury if they are tank-mixed with Captan or sulfur because the latter two fungicides kill cells if they penetrate fruit or leaf tissue.

Leaves and fruit are especially susceptible to spray injury during the period from late bloom through first cover. Tank mixes used during that period often include several fungicides, plant growth regulators (i.e., Apogee and thinners), insecticides, foliar nutrients, and miracle products promoted by suppliers. Given the combination of highly susceptible tissue and the complexity of the tank mixes, I believe that growers should completely avoid any use of Captan between full bloom and second cover. Mancozeb fungicides, which can be applied seven times at the rate of 3 lb/A with a 77-day PHI, can effectively substitute for Captan during that time, thereby significantly reducing risks of spray injury during the period when most phytotoxicity problems occur in commercial orchards. In addition, complex mixtures with Captan should be avoided in late-summer when liquid calcium products and spray adjuvants may carry Captan into fruit lenticels. Captan carried into lenticels may produce lenticel spots that appear some after spraying as well as sub lethal damage that appears only during storage.

Table 1. Mode-of-action groups and risk factors for fungicides registered on apples

| Trade name(s) | Fungicides or fungicide groups | FRAC group code | Resis-tance risk[*] | Phytotoxicity risk | Comments |
|---|---|---|---|---|---|
| Basicop, Badge, Champ, COCS, Cuprofix, Kocide, Nordox, etc | Fixed copper fungicides | M-1 | L (none?) | L at silver tip or green tip; H after green tip (GT) | Applications after green-tip may cause fruit russetting. |
| Mastercop, Phyton 27AG, CS2005, | Copper sulfate (label limits = low $Cu^{++}$ rates) | M-1 | L (none?) | M-H (after GT) | Label limitations make these unsuitable for green-tip sprays. |
| (various) | sulfur | M-2 | L (none?) | H (with oil or penetrants) | Organic farms or mildew; High rates reduce yield. |
| Captan | Captan | M-4 | L (none?) | H (with oil or penetrants) | Phytotoxic if mixed with the wrong products. |
| Dithane, Penn-cozeb, Manzate, Polyram | Mancozeb, metiram | M-3 | L (none?) | L | Best contact fungicides for tank mixes, especially bloom to 2nd cover. |
| Ziram | Ziram | M-3 | L (none?) | L | Captan work-around for oil sprays in summer. |
| Syllit | Dodine | U-12 | L-M | L | New label restriction: apply only between green tip and pink bud. |
| Topsin M | Thiophanate-methyl | 1 | H | L | Used with captan for summer diseases/rots. |
| Vangard, Scala | AP | 9 | M | L | Prebloom with mancozeb |
| Flint, Sovran | QoI | 11 | H | L | Resistance in scab (and mildew?) increasing. |
| Indar, Nova, Pro-cure, Topguard | DMI | 3 | M | L (except Topguard ??) | Resistance to scab/ mildew widespread |
| Inspire Super | DMI + AP | 3 + 9 | M[†] | L | Weak on mildew |
| Fontelis | SDHI | 7 | M-H | ?? | Phyto with captan ? |
| Pristine | SDHI + QoI | 7 + 11 | M[†] | L | Questionable for scab control where QoI-resistance is already present. |
| Merivon[**] | SDHI + QoI | 7 + 11 | M[†] | ?? | |
| Luna Sensation[**] | SDHI + QoI | 7 + 11 | M[†] | L-?? | |
| Luna Tranquility[**] | SDHI + AP | 9 + 11 | M[†] | L-?? | Weak on rust diseases? |
| Omega[**] | fluazinam | 29 | L | L-?? | Captan substitute? |
| Phosphorous acids | Phosphonates | 33 | L | L-M | For Phytophthora (and with Captan, for SBFS). |

[*]Resistance risk listed on FRAC website except that combination products ([†]) are estimated from the component fungicides and anticipated use strategies on apples. Abbreviations: L = low, M = moderate, H= high risk; Question marks indicate some uncertainty.

[**] Not yet labeled in NY

## Implementation of Precision Chemical Thinning in NY

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Several NY fruit growers and consultants attended a precision chemical thinning workshop on May 1, 2013, at the Agricultural Research Station in Geneva and agreed to participate in an improved method of conducting chemical thinning this year called ***"Precision Chemical Thinning".*** The new method utilizes both the carbohydrate model and the fruit growth model to apply a series of chemical thinning sprays to achieve a predetermined number of fruit per tree. The 2013 method uses the carbon balance model as a tool for predicting response prior to application of thinners and the fruit growth rate model for early assessment of thinning response immediately following application of thinners.

A short summary of the method is (1) select a mature orchard of either Gala or Honeycrisp, (2) count flowering clusters on 5 representative trees at pink, (3) calculate the desired number of fruit per tree based on the number of trees per acre and the yield and fruit size you expect, (4) tag 15 representative spurs per tree on each of 5 representative trees (75 total spurs) at pink or during bloom, (5) choose one of two spray protocols of thinning sprays (see below Tables 1 and 2), (6) use the carbohydrate model to adjust rates up or down based on model recommendation (model is now online at the NEWA website http://newa.cornell.edu), (7) measure fruit diameters on 75 spurs 6 times (3 and 8 days after petal fall spray, 3 and 8 days after 12mm spray, and 3 and 8 days after 18mm spray), (8) send the data within 24 hours after each 8 day measurement to Terence Robinson (tlr1@cornell.edu) and Mario Miranda Sazo (mrm67@cornell.edu), and (9) get back an assessment within 24 hours of thinning progress before next spray.

Table 1. Two options in 2013 for Precision Thinning of Gala

| **Option 1 (more aggressive and recommended for the good bloom expected for this year)** | **Option 2 (less aggressive)** |
|---|---|
| Apply a Bloom Spray (Maxcel 96oz/acre) | Apply a Petal Fall Spray @6mm (NAA 6oz/acre + Sevin 2pt/acre) |
| Apply a Petal Fall Spray @6mm (NAA 6oz/acre + Sevin 2pt/acre | Apply a 12mm Spray (Maxcel 96oz/acre + Sevin 2pt/acre) |
| Apply a 12mm Spray (Maxcel 96oz/acre + Sevin 2pt/acre) | Apply a 18mm Spray (Maxcel 96oz/acre + Sevin 2pt/acre + Oil 1pt/acre directed to the upper part of the tree) |
| Apply a 18mm Spray (Maxcel 96oz/acre + Sevin 2pt/acre + Oil 1pt/acre directed to the upper part of the tree) | |

Table 2. Two options in 2013 for Precision Thinning of Honeycrisp

| **Option 1 (more aggressive and recommended for the good bloom expected for this year)** | **Option 2 (less aggressive)** |
|---|---|
| Apply a Bloom Spray (Maxcel 48oz/acre) | Apply a Petal Fall Spray @6mm (NAA 8oz/acre + Sevin 2pt/acre) |
| Apply a Petal Fall Spray @6mm (NAA 8oz/acre + Sevin 2pt/acre | Apply a 12mm Spray (NAA 6oz/acre + Sevin 2pt/acre) |
| Apply a 12mm Spray (NAA 6oz/acre + Sevin 2pt/acre) | Apply a 18mm Spray (Sevin 2pt/acre + Oil 1pt/100gallon, directed to the upper part of the tree) |
| Apply a 18mm Spray (Sevin 2pt/acre + Oil 1pt/100gallon, directed to the upper part of the tree) | |

With whichever option chosen, you will use a stepwise thinning program of spraying and then assessing the effect before deciding on the need for the next spray. Before each spray, you will run the carbohydrate model to determine the specific thinner rate for your orchard (start with the base rate listed above in the option you chose and then adjust up or down depending on the output recommendation from the carbohydrate model). After spraying you will determine the effect of the thinning spray by using the fruit growth rate model which entails measuring the diameter of each fruit in 75 clusters on day 3 after spraying and day 8 after spraying and using a spreadsheet to calculate the thinning effect of the spray (There is a very precise methodology for these measurements and you must have some training to do this portion of precision thinning). With these results you then decide on the need for the next spray in the protocol and repeat the cycle if another spray is needed. In some cases only the first and second sprays in the protocol will be needed but in other cases 3 or even 4 sprays from the protocol will be needed to achieve the target fruit number.

**An Update on Fruit Measurement Studies by May 31st 2013**

Growers should use slightly reduced rates (15-30%) for the next few days. If it really gets to the 90's then growers should delay thinning until temperatures moderate.

The results of fruit diameter measurements made by several cooperating NY grower and consultants after petal fall thinning sprays around May 19th or 20th show that the sprays provided significant thinning on Gala and Honeycrisp but that additional thinning is still needed. In these blocks where fruit size was measured on day 3 and day 8 after the thinning spray, Gala and Honeycrisp fruit set on mature trees was reduced by about 70%, however the target is to reduce fruit set by 90%. Thus substantial thinning on Gala and Honeycrisp still remains to be done. This suggests another spray in these blocks. These results suggest what might be done in similar blocks with excellent bloom and set. Of course, you know best conditions on your farm and how individual blocks respond to thinners.

The high temperatures which are forecasted are creating a moderate carbohydrate deficit which suggests reduced rates depending on how high the temperatures go. If temperatures reach 90°+ then we suggest delaying thinning sprays until temperatures moderate. Since the weather forecasts change regularly and that affects the apple carbohydrate thinning model, we suggest that growers check the model each day but especially immediately before spraying to get the best estimates of thinning effect. If the forecasted conditions aren't achieved then the thinning prediction will be wrong. This is one of the risks of having a model using forecasted data and then having growers not check it regularly.

The carbohydrate model is now available on the web at the NEWA website (http://newa.cornell.edu) under the crop management tab. Run the model before each thinning spray and adjust thinner rate based on the recommendation in the last column of the page. The four very simple steps are: (1) Go to the NEWA Apple Carbohydrate Thinning Model Page, (2) Choose a station and click “Continue”, (3) Enter your green tip (@ April 16-17) and full bloom dates (@ May 7-8) and click “Calculate”, (4) Move the scroll bar on the right to find today’s date on the table. The last column gives the recommended adjustment in thinning rates for today based on the model. The model is limited by the accuracy of the forecasted temperatures and sunshine, which change daily.

***Note:*** This information was provided to growers via a biweekly publication called “Fruit Fax” produced by the Lake Ontario Fruit Program, Cornell Cooperative Extension. The presentation will include the results of 8 field studies conducted as part of a precision chemical thinning group effort during May 2013 in NY State.

**Building the Perfect Orchard – Experiences with Orchard Establishment in Nova Scotia**

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The first apple trees planted in North America were in Nova Scotia's Annapolis Valley in the early 1600's. One would think that after 400 odd years of growing apples that we would finally have it right!

For most of the last four centuries our industry was based on the large seedling or "standard" tree's, with a density of 40 -100 trees per acre. The development of the Malling series of dwarfing rootstocks in the 1960's led to a flurry of activity in planting a number of good sized orchards on mostly semi-dwarfing stocks. The problem was, there was very little done in the way of land preparation and the trees were widely spaced, often at 100-150 trees/acre.

About this time a disorder known as Specific Apple Replant Disease began to appear. Basically what happened is that the new trees which were planted in place of the grand old towering trees failed to grow in the first two or three years after planting. A complex of soil borne pathogens was identified as the cause, rather than high nematode levels which have been implicated in other areas. Some orchards were fumigated prior to planting, but only to a depth of 6-8". The trees continued to be planted at fairly wide spacing's in hopes that they would eventually fill their space. In most cases this never happened, and the average per acre production never reached an economically sustainable level. We were also planting low valued varieties such as McIntosh, Cortland and Ida Red, which did not help the situation. The industry started to decline, and was well on its way to becoming insignificant.

In the mid 1990's we recognized that we had to do something. We started travelling around the world to see what we were doing wrong. Following a trip to South Africa, we realized that significant improvements were well within our reach. We hired a soil scientist from South Africa to come work with us for a two-year term and he liked it so well that he never went home.

We started out by identifying blocks that were losing money and removed the trees. We then went in and dug test holes with a backhoe in a grid across the property. Soil samples were taken at various depths and sent for chemical analysis. Problems such as soil compaction or poor drainage were identified. A deep ripping plow was constructed, and where required the soil was ripped and/or mixed to a depth of 48" using a bulldozer to pull the plow. The rows were then formed into ridges using a blade or a specially designed set of disc harrows.

It was identified that we were not fumigating the soil to a depth where the bulk of the roots were growing. To correct this, we purchased and modified a deep shank fumigator that placed the material deeper in the soil profile.

Poor quality nursery stock was the rule rather than the exception in our area. To correct this, we began to import high quality, large caliper trees from the United States. Small trees were rejected by the farmers at delivery. These were planted closer together and in very straight rows using GPS guided tractors and tree planters.

No more free standing trees were planted. Even semi-dwarfing stocks had the tops supported with simple yet effective trellis systems. No more single trees stakes were used as these were prone to leaning and breakage. At close spacing's the trees needed to remain upright or the system became unmanageable. The most common system consists of a two wire trellis with a leader support attached to each tree. This was usually an electrical conduit attached to the wires with a special high tensile clip. Bamboo and 12.5-gauge wire have also been tried with varying degrees of satisfaction. The trellis is supported by 12' pressure treated poles driven 30" in the ground spaced every 30-40'in the row. Fourteen-foot poles driven 4' in the ground are used on each end. These are angled back about thirty degrees off vertical. The poles are driven with a plate tamper affixed to the boom of an excavator.

A 48" long screw in anchor is used at each end, with ratchet tighteners used to keep the wire tight. Various four and six wire trellises have been tried, but the growers have tended to be unhappy with the constraints on movement imposed by these systems. However, once the spacing drops to less than 2' these systems become more attractive from a cost standpoint.

An intensive irrigation study was undertaken, measuring soil moisture levels and tree growth in various soil types. It was ascertained that irrigation was beneficial in some cases, but only in our lightest soils. Systems were installed in areas that required them.

So then an amazing thing happened. When we prepared the soil properly, planted good trees close together and supported them properly, we began to grow a lot of apples on a little area. In fact we could grow almost as many apples per unit area as the other apple growing regions. We had been using the excuse of climatic limitations to production for so many years that we actually started believing it. All of a sudden we were producing 1000-1200 bushels per acre instead of 400 bushels per acre, which was the historic provincial average.

When we combined the high annual production with high value varieties such as Honeycrisp the industry began to grow. There were some growers who did not embrace this way of growing apples and most of them are now gone or will be shortly. Those who did are financially stable and many have children who are anxious to get into the business. What a far cry from where we were twenty years ago.

**Prevention and Management of Viruses in Cucurbit Crops**

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A complex of viruses can cause devastating diseases and affect the profitability of cucurbit crops in the northeastern U.S. Aphids are the primary vectors for the major viruses that attack cucurbits. The use of high quality seeds and resistant cultivars are some of the measures that should be considering in preventing and managing viruses in cucurbit crops.

**Major Viruses of Cucurbit Crops.** Major viruses of cucurbit crops in the northeastern U.S. are *Cucumber mosaic virus* (CMV), *Watermelon mosaic virus* (WMV) and *Papaya ringspot virus* type w (PRSV). CMV is the most widely distributed and most important virus in cucurbit crops followed by WMV and PRSV. Mixed infection by CMV and WMV can be common. Minor viruses in cucurbit crops in the northeastern U.S. are *Squash mosaic virus* (SqMV), *Tobacco ringspot virus* (TRSV), *Tomato ringspot virus* (ToRSV), *Zucchini yellow mosaic virus* (ZYMV), and *Clover yellow vein virus* (CYVV).

**Effect of Viruses on the Performance of Cucurbit Crops.** Viruses can reduce plant growth and cause substantial yield losses in cucurbits crops. Fruits are smaller in size, distorted, mottled, and/or discolored, and thus, are not marketable. The effect of viruses on crop performance is often more severe at a very early development stage. As a consequence, yield losses can be dramatic if infection occurs at a pre-bloom development stage. In contrast, marketable fruits can usually be harvested if virus infection occurs at a post-bloom development stage, although foliar symptoms can be dramatic. There is no cure for virus-infected cucurbits in the field; once a vine is infected by a virus it will remain infected for the duration of the planting.

Diagnostic foliar symptoms consist of chlorotic mottle, distortion, mosaic, green mosaic, blistering, and downward cupping. However, it is difficult to attribute symptoms to one specific virus because mixed infections, in particular with CMV and WMV, are common. Only laboratory tests can reliably identify viruses in cucurbit crops.

**Transmission of Viruses by Aphids in Cucurbit Fields.** Aphids transmit most of the viruses (CMV, WMV, ZYMV, PRSV and CYVV) in cucurbit crops. Spring aphid flights are important for disease spread in and between fields. Several aphid species can vector viruses, although most of them do not colonize cucurbit crops and do not cause direct, serious injury.

The transmission mechanism by which aphids transmit viruses is well characterized. It takes a limited time (a few seconds to less than one minute) for the virus to be acquired and further transmitted from plant to plant. Often a few plants become infected early in the season and these initially infected plants serve as primary virus source for secondary aphid-mediated spread. A viruliferous aphid can retain the virus for a short time (less than one hour). However, it can potentially carry it over long distance.

When visiting a cucurbit, aphids make two types of probes on the surface of leaves, test probes and feeding probes. Virus transmission occurs during rapid test probes and not during longer-lasting feeding probes. During test probes, the virus is sucked into the aphid's stylet where it can stick to the lining of the food canal. If the aphid moves to a susceptible healthy plant and initiates a test probe, the virus can detach and be released when the content of the food canal is expelled. Viruses do not increase in the aphid and do not circulate within the aphid's body. Viruliferous aphids lose viruses if they probe on nonhost species. In the northeastern U.S., CMV is often the major culprit in cucurbit crops early in the season followed by WMV later in the season.

**Other Transmission Means of Viruses in Cucurbit Crops.** None of the viruses in cucurbit crops is transmitted through seeds, except SqMV, which is seed-borne in melon. SqMV is transmitted by cucumber beetles whereas TRSV and ToRSV are transmitted by the dagger nematodes *Xiphinema americanum*.

**Weeds as Virus Reservoirs.** CMV and WMV, the two major viruses of cucurbit crops in the northeastern U.S., as well as TRSV, ToRSV and CYVV, can overwinter in many weeds, including annuals (pigweed, milkweed, horseweeed and Sherperd's purse) and perennials (milkweed, sowthistle, dandelion, chickweed and clover), among others. Infected weeds can serve as primary reservoir for viruses in cucurbit crops. As a result, virus epidemics in cucurbit crops can originate from infected weeds that are visited by aphids.

**Management Recommendations of Viruses in Cucurbit Crops.** Due to the mechanism of virus transmission by aphids, insecticides are of limited efficacy at limiting aphid vector populations. Actually, the use of insecticides is not recommended for the control of aphid-borne viruses in cucurbit crops unless epidemics are severe. Adjusting the planting date, i.e. delaying the timing of planting after the peak of aphid flights, and the use of reflective mulches to deter aphid vectors in combination with stylet oils to prevent aphid probing can help mitigate the impact of viruses although severe epidemics may not be prevented.

The use of resistant cultivars is the most effective control measure. Resistance to multiple viruses is desirable because mixed infections are common. Resistance to viruses is available in several cucurbit crops cultivars.

In cucumber (*Cucumis sativus*), resistance to CMV has been successfully incorporated into numerous cultivars by conventional breeding, and resistance to CMV, WMV, ZYMV and PRSV is available in cultivars Cobra, Cortez, Cutter, Darlington, Diomede, Eureka, Fortune, Indio, Indy, Lider, Mcpick, Orient Express, Sultan, Supremo, Talladega, Thunderbird, Viper, Zapata and Zipangu.

In yellow summer squash (*Cucurbita pepo*), resistance to mixed infection by CMV and WMV, or CMV, WMV and ZYMV, or CMV, WMV, ZYMV and PRSV has been developed through conventional breeding techniques (cultivars Cougar and Lioness) and biotechnological approaches (cultivars Conqueror III, EX 1832 III and Liberator III). Similarly, in zucchini squash, resistance to CMV or ZYMV or WMV and ZYMV, or PRSV and ZYMV, or CMV, WMV and ZYMV or WMV, PRSV and ZYMV, or CMV, WMV, ZYMV and PRSV has been achieved through conventional breeding techniques (cultivars Linda, Paycheck, Plato, Radiant and Reward) and biotechnological approaches (cultivars Justice III and Judgement III).

In muskmelon (*Cucurbita melo*), limited resistance to WMV, PRSV and ZYMV is available (cv. Hannah's Choice and Sugar Cube). In pumpkin, resistance to ZYMV, or WMV, PRSV and ZYMV, or CMV, WMV and ZYM is available (cultivar Munchkin).

In winter squash (*Cucurbita moschata* and *Cucurbita maxima*), limited resistance to ZYMV is available (cultivars Speckled Hound and Speckled Pup).

In watermelon (*Citrullus lanatus*), no source of resistance is recognized in commercial cultivars.

For SqMV, the selection of disease-free seeds and management of striped and spotted cucumber beetles is recommended for management purposes. Control of cucumber beetles is important as these insects also vector the causal agent of bacterial wilt in cucumber, squash, muskmelon, pumpkin and gourd.

**Conclusions.** Based on the ecology of viruses in cucurbit crops and the fact that there is no cure for virus-infected cucurbits in the field, a careful selection of resistant cultivars and high quality seeds is recommended to prevent viral diseases and mitigate their impact. Managing weeds that can serve as virus reservoirs can delay disease development. However, numerous annual, biennial and perennial species should be targeted in order for this strategy to be effective. Also, weeds should be controlled not only at the farm level but also at a regional scale for this virus management strategy to be beneficial. This might not be feasible and economically viable. Under consistently severe epidemics, adjusting the planting date and using reflective mulches in combination with stylet oils are other options that can help delay the onset of disease.

## Reduced Tillage Techniques in Cucurbit Crops

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### Background:

For about 10 years, we've been doing no-till and/or reduced-till growing on our farm. We started on popcorn and Indian corn. After confirming that we could establish a respectable stand, we moved on to sweet corn. We've now done no-till sweet corn with pretty good success for 8 or 9 years. Cucurbits have been more of a challenge, most likely due to the smaller number of effective herbicides available compared to corn. But we now have had 2 or 3 successful years of no or zone-till for cucurbits. We are really happy to say that the crop quality is so much better, cleaner and healthier that we won't be doing much bare ground again for pumpkins.

So…the impetus for trying this newish tillage technique was really straightforward…We needed to increase soil organic matter. We had seen, after years of vegetable production with conventional tillage, our soil organic matter levels fall down into the 2% range. We then started seeing all the problems that can go along with that:

- Little water holding capacity
- Increased disease pressure
- Poor nutrition
- A little soil erosion

### Technique:

Our no-till technique is simple and inexpensive. I'd like to thank Nate Nourse for showing me some simple modifications to our Monosem Planter. The three additional parts that we put on and off our Monosem Planter are:

1. Fluted coulters mounted on front of the planting unit (3 bolts)
2. Down pressure springs, also simple
3. Heavier (cast iron) packing wheels for getting the trench to close

Most of the Potassium is broadcast in April on to a thick stand of Rye, which we allow to grow until near the end of May. We spray glyphosate to kill in May or early June. (Broadcasting can be tricky to see where you are going.)

The next is planting—The real leap of faith—achieving good seed to soil contact at the correct spacing is always your goal. These parts have made it very doable.

Achieving good weed control was the next challenge. Relatively easy with no-till corn, but not as many options in pumpkins. Sandea, Strategy (at the max labeled rate) and Gramoxone* to smoke any emerged weeds (before crop emergence) has been what's worked for us.

Cucumber beetle management is the same as bare ground.

Most of the Nitrogen requirements are broadcast just before running. This is a little less than ideal but we try to time it with a nice rain and have met the crops Nitrogen needs this way. We do get a little bit of leaf damage, but not too much.

Then, fungicides for disease control just like on bare ground.

The Zone-till technique entails all the same steps, minus the additional parts on the planter, but add the pass with the Zone Builder.

**Results:**

We knew that there would be great benefits to increasing soil organic matter and this is what we found:

- The big one is improved water holding capacity of the soil. We rarely need to irrigate our no-till fields, while at the same time we are running franticly to keep the bare ground parts of our sandy farm watered during hot spells.
- Improved drainage, which may not sound obvious but I quite dramatic. There is no puddling, no soil erosion and much better disease control.
- Better quality fruit from better disease control, specifically Phytopthera and little or no dirt on the fruit.
- We have reduced fuel/time in field preparation during a very busy planting season.
- More complex and active soil biology which I know would be difficult to put a finger on, but I know it is still important.

There are a few disadvantages.

- The soil is slow to warm in the spring, so no-till not zone-till may not be appropriate for early plantings.
- In the no-till, thick organic matter can sometimes ball up in planting, making good seed to soil contact difficult, reducing germination.
- The biggest disadvantage is that this method is reliant on chemical weed control; options for later cultivation are limited.
- Adding nutrients later can be more difficult.

Overall, we feel that we have turned a corner and have become fond of our no-till and zone-till planting techniques.

## Monitoring for Squash Vine Borer in New Hampshire

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Squash vine borer [*Melittia cucurbitae* (Harris)] is a day-flying orange and black moth. The destructive stage is the larva (caterpillar), and it attacks most types of squash and pumpkin.

### Damage

Usually the insect bores through the vines, but occasionally they bore into the fruit of hard squash or pumpkin. The fruit feeding is especially seen when there is a late flush of moths. Plants with significant boring frequently show yellowish-orange frass being pushed out of the vines. When that occurs, the vines have already incurred considerable injury. Damage can be severe which greatly reduces yield.

### Varietal Differences

Zucchini and summer squash [*Cucurbita pepo*] are **very susceptible** to attack. Since pumpkins are the same species, they are susceptible. Giant pumpkins and Kubocha squash [*Cucurbita maxima*] are also susceptible. The moths do not like to lay eggs on Butternut squash [*Cucurbita moschata*], and larvae that do attack it do not survive well, so it is called "resistant." Usually, plantings of this species do not require any squash vine borer (SVB) protection. Bush-type varieties seem to suffer more than vine-types, within the same group. Vine-type plants often root at the nodes, and this may lessen the effect of the larvae boring in the stems.

### Life Cycle

This insect has one generation per year. It overwinters in the soil, usually about two inches down, as a larva or pupa. In late June, the adult moths begin to emerge. They are bright red-orange, with plump bodies and narrow black wings. Body length is about 12 – 14mm (roughly ½ inch). The shape is very wasp-like. Soon after mating, the females locate squash/pumpkin plants by smell, and lay their eggs singly (not in masses) on the vines, leaf stems, and underside of leaves. Eggs are reddish brown and oval, about 1mm long. Each female can lay 150 to 200 eggs, and the moths are fairly strong fliers. Eggs hatch in 10 – 15 days, and the tiny caterpillars bore inside. The larvae take four to six weeks to mature. When fully grown, they are about an inch long, cream colored, with dark brown heads. They leave the vine and bore into the soil to build a cocoon and pupate. They rest there until the following summer, when the adult moths emerge.

In the southern United States, this insect has two generations each year. In New England, although we expect only one generation, we have found a very late peak (August 22 – 30) of moths in 2010 and 2013, that might represent a second generation.

## Traps to Monitor Timing and Numbers

Research shows that shallow pans painted yellow and filled with water can attract and capture the moths. However, commercially-available pheromone traps and lures are more reliable for monitoring. We use white dacron net traps, called Heliothis traps that were originally designed for corn earworm (*Heliothis zea*). These traps are baited with a lure that releases a sex pheromone that attracts the male SVB moths. Although bucket-type traps are offered to monitor SVB, our tests reveal they catch far fewer SVB moths than the *Heliothis* traps, so we do not recommend them.

Normal recommendations were to place the Heliothis traps (net-type of trap) with Squash Vine Borer pheromone lures in the field after July 4. At some of the farms, the traps were placed in the fields the first week of June. The first trapped male squash vine borer was observed the second week of June, which was two to three weeks prior to the recommended date that traps should be set. Normally, one would expect the last squash vine borers would be seen mid to end of August. The last squash vine borer insect caught was during the week of September 28.

If a conduit pipe is used for support, you may want to add duct tape over the tie points to prevent the trap from sliding downwards. The bracing line that goes to a stake in the ground should be slightly slack to provide some support in windy conditions. Distance from the ground to the trap bottom should be about two feet. The trap should go in the squash field, with squash leaves below (but not blocking) the opening. Select a spot where it will not interfere with farm equipment.

Place the pheromone lure in the middle of the opening, and level with the bottom of the trap — not hanging several inches below or above the opening. We have used several devices for securing lures in the position—safety pins, clothes pins, and small binder clips. The important thing is for it to stay in the correct position despite wind and weather, and that it's easy to change lures. The lures are individually wrapped and are stored in the freezer until ready for use. Once unwrapped and placed in the trap, they release the odor for four weeks.

The effectiveness of the green bucket trap compared to yellow/white bucket trap with both traps baited with squash vine borer pheromone lures was compared to Heliothis traps (net-type of trap) baited with the same SVB pheromone lures. Three traps of each type were placed in the same field. When comparing yellow/white bucket traps and Heliothis traps to the green bucket traps, the green bucket traps were poor in catching male moths. If growers rely on green bucket traps to guide spraying decisions, they could make erroneous decisions. The Heliothis traps (net-type of trap) caught a slightly higher number of SVB moths than yellow/white bucket trap. Based on this, we recommend the Heliothis traps but the yellow/white bucket traps can also be used. The green bucket traps should not be used.

## Thresholds

The number of moths captured (using the Heliothis traps described above) can be used to decide whether or not an insecticide treatment is required. For summer squash, the recommended threshold (the point where insecticide treatment is worthwhile) is five SVB moths per trap per week. Pumpkins can sustain this level without serious injury. For vining pumpkins, the recommended threshold is twelve SVB moths per trap per week. For bush types, five SVB moths per trap per week is the recommended threshold.

**Management Options**

Crop rotation, moving cucurbits to different fields year-to-year, can reduce problems especially if the fields are far apart. If complete skipping is too difficult for your market, consider growing less susceptible types.

Deep tillage after harvest or before planting in the spring may kill a number of the larvae/pupae in the soil. This practice can reduce the numbers, but in a heavy infestation it will not make much of a difference.

Some backyard growers report success by physically removing borers from the vines. Growers who have tried this look for frass being pushed out of the vines. Then they carefully make a small lengthwise cut in the vine, and remove the borers. Next, they wrap the cut together and hope for the best. Some cover the vine at that spot with soil, which can encourage rooting. However, manual borer removal requires too much labor for most commercial growers to follow.

Remove dying vines! If you remove and thoroughly destroy vines that are heavily attacked and dying, this prevents the larvae inside from completing their development, and emerging as moths next year.

Spun-bonded row covers or netting can completely exclude the moths from laying eggs, but they also exclude pollinating insects. If you want to use netting or row covers to control the borers, they must be up during the pollination period or no fruit will be produced.

Finally, the borers can sometimes be controlled by injecting the insect-attacking nematodes Steinernema carpocapsae into damaged vines.

**Chemical Control**

The current *New England Vegetable Production Guide* lists insecticide choices, which are subject to change. Insecticides can be very effective in controlling this SVB, but they must not be applied right when pollinators are also visiting the plants. Therefore, pesticide use should be limited to situations when it is really needed (for example, insecticides should not usually be used on butternut squash). Also, try to eliminate the use of insecticides that are especially hazardous to bees. Spraying very late in the day may slightly reduce the risk to honey bees.

Perimeter trap cropping can work but usually requires too much effort to be practical. This can reduce SVB attack on a large field if no cucurbits were grown there the previous year. Plant a wide border of a highly preferred variety (blue hubbard squash) completely surrounding the field of summer squash, and then heavily spray the blue hubbard squash plants when borers are flying. More details can be found on this from by Jude Boucher, University of Connecticut are at **www.hort.uconn.edu/ipm/veg/htms/directptc.htm**.

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# Disease Management in Cucurbit Crops

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Every year in the northeast, cucurbit crops are potentially affected by more diseases than most other vegetable crops. All cucurbits at a minimum are affected by powdery mildew due to the quantity of easily wind-dispersed spores that the pathogen produces. Pathogens causing other diseases are not as widely dispersed. Several can survive in the soil, thus rotation is an important management practice. Most diseases are more severe during a rainy than dry season because wet leaves or soil are favorable conditions for most pathogens (exceptions include powdery mildew, bacterial wilt, and virus diseases). Successful management is based on knowledge of pathogen biology, in particular sources of inoculum and conditions favoring disease development, which is used to identify appropriate cultural management practices. Knowing early symptoms facilitates early detection. It is also important to have current information on fungicides and resistant varieties. Below is information on select diseases followed by an integrated management program. See also: vegetablemdonline.ppath.cornell.edu .

**Phytophthora blight**. This destructive disease has more severe recently in areas where there were intensive rainfall events, which created unusually favorable conditions. A key to successfully managing this disease is managing soil moisture to avoid saturated conditions. Achieving this is difficult when rainfall amounts are large. Another key has been fungicides registered in recent years with targeted activity for pathogens in this biological group (Oomycetes): Forum (FRAC Code 40), Revus (40), Tanos (27), Presidio (43), Ranman (21), Gavel (22), and phosphorous acid fungicides (33). These are considered the reason many growers have been effectively managing Phytophthora blight. A preventive fungicide program is considered essential. Ineffective control with fungicides has been associated with poor application timing in some fields (application missed when rain began before expected) while in others favorability of environmental conditions seemed to have been too great. Development of fungicide resistance is a concern with all targeted fungicides due to single site mode of action; therefore, alternation amongst chemistry is recommended. Resistance to Ranman has been detected in the southeastern US. Protectant fungicides, such as coppers, are not sufficiently effective to be recommended alone for Phytophthora blight; however, they are useful tank-mixed with targeted fungicides to manage resistance. Presidio has a long rotational interval of 18 months for non-labeled crops, which can be a constraint on its utility. Most vegetable crops are now on the primary or supplemental labels. An important notable exception is sweet corn, which is commonly grown in rotation with pumpkins. There are also now several biopesticides (include Actinovate, Double Nickel, Regalia, RootShield, Serenade Soil, and Bio-Tam) that can be applied to soil pre-transplant, at planting, and via drip to manage the blight pathogen, *Phytophthora capsici*, in the root and crown zone and to induce resistance (Regalia). Most of these biopesticides can also be applied to foliage.

Typically Phytophthora blight begins to develop in low areas where water drainage is poor, but symptoms have been found first in sloped areas. This documents the need to look throughout a crop for symptoms and not focus exclusively on low areas. It is better to avoid planting low areas. While crops planted in a field lacking the pathogen (based on crop and disease history) typically will be free of Phytophthora blight, this is not absolute. The pathogen can be moved between farms via water. Two cultural practices that have proved useful are biofumigation and deep zone reduced tillage. Biofumigation can be accomplished by growing a biofumigant mustard cover crop typically in early spring, chopping into small pieces 4-6 weeks after onset of flowering, and immediately incorporating the mustard, then sealing the soil surface with a culti-packer and irrigation. Plant after at least 7 days.

**Powdery mildew**. An integrated program with both management tools (resistant varieties and fungicides) is recommended to maximize likelihood of effective control. Evidence has been obtained that the pathogen is evolving and becoming less effectively controlled by currently-available tools. Alternate among targeted, mobile fungicides in the following 4 chemical groups (see list below), and apply with protectant fungicide to manage resistance development and avoid control failure if resistance occurs, and also to comply with label use restrictions. Note that the main goal is delaying resistance development, not managing resistance. Begin very early in powdery mildew development (one older leaf out of 50 with symptoms).

Torino (FRAC Code U6) is a new fungicide with a new mode of action. It has exhibited excellent control in fungicide evaluations conducted recently. Activity is limited to powdery mildew. It can only be applied twice to a field in a 12-mo period. Consecutive applications are not recommended. REI is 4 hr. PHI is 0 days.

Quintec (Code 13) has been consistently effective in fungicide evaluations. Activity is limited to powdery mildew. Labeled crops are pumpkin, winter squash, gourd, and melon. The crop rotational restriction is 12 months. Recent crop additions to the Quintec label have increased the options of what can be planted within 12 months of the last application. The Quintec label specifies no more than two consecutive applications plus a crop maximum of four applications. It is the only fungicide in this chemical group available in the USA. REI is 12 hr. PHI is 3 days.

DMI fungicides (Code 3) include Procure, Rally, Tebuzol, Folicur, and Inspire Super. Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Efficacy has varied in fungicide evaluations. Procure applied at its highest label rate provides a higher dose of active ingredient than the other Code 3 fungicides. Five applications can be made at this rate. REI is 12 hr. PHI is 0 days. Powdery mildew is the only labeled cucurbit disease for these fungicides, except for Inspire Super, which contains another active ingredient (Code 9) and is labeled for additional diseases. PHI is 7 days.

Carboxamide fungicides (Code 7) currently registered are Pristine, Fontelis, and Luna fungicides (all 4 Luna formulations are labeled for use only on watermelon so far). Strains of the powdery mildew pathogen resistant to Pristine have been detected and likely are the reason its efficacy has varied. All are labeled for additional diseases. Fontelis can be applied 4 times at highest labeled rate with no more than 2 consecutive applications. REI is 12 hr. PHI is 1 day. Cross resistance has documented between Pristine and Fontelis, but not Luna.

Resistance continues to be very common to MBC fungicides (FRAC code 1; Topsin M) and QoI fungicides (Code 11; Quadris, Cabrio and Flint); therefore, these continue to not be recommended. There are several protectants for powdery mildew, including chlorothalonil, sulfur, copper, botanical and mineral oils, and several biopesticides.

**Plectosporium blight**. This disease occurred more commonly in 2011 than previous years, reflecting that rainy weather provided favorable conditions. Rotate, clean equipment between fields, apply chlorothalonil before rain, and incorporate infested debris right after harvest.

**Downy mildew** is primarily managed with fungicides. Resistance bred into cucumbers provides some suppression of the pathogen strains present recently, but substantially less that what was achieved against strains present before 2004. However, they are still considered a worthwhile component of an integrated program. As with powdery mildew, fungicide resistance is also a concern with the downy mildew pathogen and therefore the fungicide program recommended is also targeted, mobile fungicides applied in alternation based on FRAC Code (see list below) on a weekly schedule and tank mixed with a protectant fungicide (chlorothalonil or mancozeb) beginning very early in disease development.

An important tool for determining when fungicide application is warranted is the forecast web site for this disease at http://cdm.ipmpipe.org. Cucurbit plants are susceptible to downy mildew from emergence; however, this disease usually does not start to develop in the northeast until later in crop development when the pathogen is dispersed by wind into the region. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. The pathogen needs living cucurbit crops to survive, thus it cannot survive where it is cold during winter. The risk of downy mildew occurring throughout the eastern USA is forecast and posted three times a week. Forecasts enable timely fungicide applications. Label directions for some fungicides state to begin use before infection or disease development. The forecasting program helps ensure this is accomplished. Growers can subscribe to receive customizable alerts by e-mail or text message. Information is also maintained at the forecast web site of cucurbit crop types being affected by downy mildew. This is important because the pathogen exists as pathotypes that differ in their ability to infect the various crops. All pathotypes can infect cucumber; some also can infect melons and squashes are susceptible to others. Success of the forecast system depends on knowledge of where downy mildew is occurring; therefore prompt reporting of outbreaks by growers is critical.

Presidio (FRAC Code 43). This has been the most effective fungicide. However, it has provided less suppression than expected in fungicide efficacy trials conducted recently when the original source of the pathogen for the season is southeastern US; Presidio remains highly effective against mid-west strains. See cdm.ipmpipe.org to determine likely source. It is prudent to use it judiciously in a good rotation program. Apply no more than 4 times in a season with no more than 2 consecutive applications. Must be applied with another fungicide.

Zampro (40, 45) and Revus (40). While in the same fungicide chemical group, there is indication they may have slightly different mode of action, thus there may be benefit to using one for the first application of a product in this group in a fungicide program and then switching to the other product later in the program. REI is 12 hr. PHI is 0 day. Apply no more than 3 times (4 for Revus) in a season with no more than 2 consecutive applications (none with Revus). Revus must be applied with a spreading/penetrating type adjuvant.

Ranman (21). Use organosilicone surfactant when water volumes are less than 60 gallons per acre. REI is 12 hr. PHI is 0 day. Apply no more than 6 times in a season with no more than 3 consecutive applications.

Previcur Flex (28). This fungicide is more systemic than others and has good activity for downy mildew, but it is not effective for Phytophthora blight, which usually is also a concern in cucurbit crops. REI is 12 hr. PHI is 2 days. Apply no more than 5 times in a season.

Curzate or Tanos (27). These have some curative activity (up to 2 days under cool temperatures) but limited residual activity (about 3-5 days). They can be a good choice when it was not possible to apply fungicide at the start of a high risk period when temperature is below 80 F. Apply another targeted fungicide 3-5 days later. Both must be tank-mixed with a protectant. REI is 12 hr. PHI is 3 days. Apply no more than 4 times in a season (6-9 for Curzate depending on rate); no consecutive applications of Tanos are permitted. Curzate is not labeled for Phytophthora blight.

Gavel (22). This is the only product that consists of a targeted fungicide and a protectant fungicide (mancozeb). REI is 48 hr. PHI is 5 days. Apply no more than 8 times in a season. Some cantaloupe varieties are sensitive to Gavel. Workers must be notified that a dermal sensitizer was applied both orally and by posting at entrance to treated area for 4 days.

*Recommended protectant fungicides*. Chlorothalonil and mancozeb are the main protectant fungicides for downy mildew. Copper is not as effective. Dithane now has a supplemental label that includes winter squash.

No longer recommended. Resistance to mefenoxam and metalaxyl and to strobilurins is sufficiently common that fungicides with these active ingredients (e.g. Ridomil and Cabrio), which use to be highly effective, are now ineffective.

***Integrated Management Program for Cucurbit Diseases:***

**Sign up for alerts about downy mildew occurrence** before the season at the forecast web site http://cdm.ipmpipe.org. Monitor the web site during the season for information on outbreaks.

**Select resistant varieties.** See vegetablemdonline.ppath.cornell.edu/Tables/TableList.htm.

**Use fungicide-treated seed and/or seed that has been tested for pathogens.** FarmMore commercial seed treatment also has an insecticide. Alternaria leaf blight, angular leaf spot, anthracnose, damping-off, Fusarium wilt, gummy stem blight/black rot, scab, Septoria leaf spot.

**Rotate land** to control diseases caused by pathogens that can survive in soil or on weeds in hedge rows, which include Alternaria leaf blight, anthracnose, angular leaf spot, Fusarium crown and fruit rots, Fusarium wilt, gummy stem blight/black rot, Phytophthora blight, Plectosporium blight, scab, Sclerotinia white mold, Septoria leaf spot, and viruses.

**Select a well-drained site** to manage cottony leak, damping-off, Phytophthora blight, Rhizoctonia belly rot, and scab.

**Minimize leaf wetness.** Select a site with good air movement and overhead irrigate when leaves will have time to dry before evening dew period to manage foliar diseases.

**Physically separate cucurbit plantings.**

**Avoid moving infested soil into clean fields.** Work last in fields where pathogens occur that survive in soil, then clean equipment before working in fields where these diseases haven't occurred (see list under rotate above). Apply pesticides to areas without soil-borne diseases first.

**Scout for diseases** regularly during the growing season. Focus on older leaves as diseases often start to develop there. Look on both leaf surfaces. It is especially important to scout once plants start to produce fruit. Check low areas for Phytophthora blight. Monitor downy mildew forecasts. Also look for cucumber beetles early in crop development.

**Apply pesticides as needed** (fungicides before rain for most diseases except powdery mildew):

Insecticide Admire Pro at planting or transplanting for cucumber beetles, which carry bacteria that cause bacterial wilt. Or use FarMore-treated seed. Planting Blue Hubbard or another cucurbit highly attractive to beetles around the crop to form a perimeter trap is an effective strategy that can result in insecticide only being needed on the trap plants.

Contans before or at planting for white mold.

Ridomil Gold EC (Code 4) at planting for damping-off and cottony leak. Another option for damping-off is Previcur Flex (28) and biopesticides.

Phosphorous acid fungicides (33) and/or biopesticides (see list above) at planting for Phytophthora blight.

Protectant fungicides (chlorothalonil, mancozeb, and/or copper) before disease onset. A preventive schedule is especially important with copper for angular and bacterial leaf spots.

Where bacterial wilt is a concern, apply insecticide if treatment at planting is no longer killing cucumber beetles early in crop growth, especially prior to canopy closure. Labeled products are Asana, Assail, Baythroid, Brigade, Danitol, Lannate, Pounce, Sevin XLR Plus, Volium Xpress, and Admire applied through drip.

Phytophthora blight. Alternate among the following fungicides tank mixed with copper or chlorothalonil beginning before symptoms are observed: Ranman (FRAC Code 21)*, Revus (40), Presidio (43), Zampro (40,45), Tanos (27), Gavel (22), and phosphorous acids (33).

Apply targeted fungicides in alternation based on FRAC code when the following diseases occur starting at first symptom, tank-mix with protectant fungicide:

Alternaria leaf spot. QoI fungicides (11), Reason (11), Fontelis (7), Inspire Super (3,9), Pristine (7,11), Tanos (27).

Anthracnose. QoI fungicides (11), Inspire Super (3,9), Pristine (7,11), Tanos (27), and Topsin M (1).

Belly rot. Quadris (11) and Topsin M (1).

Downy mildew. Previcur Flex (28), Curzate (40), and all fungicides for Phytophthora blight except phosphorous acid fungicides.

Gummy stem blight. QoI fungicides (11)*, Fontelis (7), Inspire Super (3,9), Pristine (7,11)*, Switch (9,12), and Topsin M (1).

Plectosporium blight. QoI fungicides (11)* and Inspire Super (3,9).

Powdery mildew. Torino (U6), Quintec (13), Procure or other Code 3 fungicide, and Luna (7), Fontelis (7)*, or Pristine (7,11)* .

Septoria leaf spot. Inspire Super (3,9).

* Resistance detected in the US.

**Hasten decomposition of infested crop debris** by chopping debris to break it up and then incorporating with disk, roto-till or plow. Do immediately after harvest.

*Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Note that some products mentioned are not yet registered for use on cucurbits. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.*

**The Nuts and Bolts of Fruit Quality in Cucurbits**

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There are several aspects of fruit quality in cucurbits, including fruit size, fruit appearance, freedom from disease, and eating quality. Fruit size and to a large extent, fruit appearance, is largely dictated by variety and cultural conditions such as plant spacing, fertility and temperature conditions during fruit growth. In this presentation, the focus will be on eating quality, which in mature cucurbit fruits is correlated with sugar content in melons and with sugar and starch content in squash.

MELONS. Different melon varieties may have different aromatic properties than contribute to flavor, but the major attribute contributing to acceptable eating quality is sugar content. Measuring sugar content is relatively expensive; however, sugar content can be estimated by analyzing a drop of fruit juice with a hand-held refractometer. This instrument gives the soluble solids content (SSC) of the juice; melons with a SSC of 11% or higher generally have enough sweetness to be judged acceptable. At UNH we have bred several early melon varieties to extend the market window for local production. Many of these are joint developments with seed companies. Varieties developed for the early market include Halona (replacement for Earliqueen), Earlichamp (replacement for Earligold), Diplomat (PMR substitute for Passport), and Goddess (early Athena type). Sarah's Choice, though a bit later than the former mentioned varieties, has achieved popularity because of its excellent taste. Several midseason varieties with UNH parentage, and more or less in the Athena class, include Dutchess, Grand Slam, Homerun, Strike, and Verona. Some more specialized cantaloupes include Wrangler, an oval Tuscan type melon with prominent but shallow ribbing and touted for its excellent flavor, and Sugar Cube, a small two-pound, consistently sweet melon with multiple disease resistance.

All of the above melon varieties have been bred for high sugar content and adaptation to growing conditions in New England and the Northeast. Nonetheless, attaining consistently high sugar levels in commercial production can often be problematic. In particular, melons are susceptible to 'Sudden Wilt', a malady characterized by severe wilting of the vines, usually occurring within a week or a few days prior to first harvest. There are two factors commonly associated with appearance of sudden wilt: (1) melon plants which have an excessively heavy fruit load in relation to vegetative growth (photosynthetic leaf area), and (2) occurrence of stress conditions such as very high temperatures, moisture stress, disease stress, and less commonly, low soil temperatures (below 62 $^{o}$F). Early varieties typically lack the vegetative vigor of midseason varieties because early fruit set suppresses later vegetative growth. Some years back we found that sudden wilt was prevented by soil fumigation. This, together with other published melon research, suggests that a soil-borne pathogen contributes to the 'sudden wilt syndrome'. One approach we are trying to circumvent some of the problems with sudden wilt is to breed melons with long shelf life (LSL) genetics. Melons accumulate sugars throughout development and sugar levels continue to rise up to the time that fruit change color and easily slip from the vine (Figure 1). Thus, if melons are picked at half-slip or earlier, or if vines wilt a few days before full-slip stage, sugar contents are likely to be too low for acceptable marketability. In

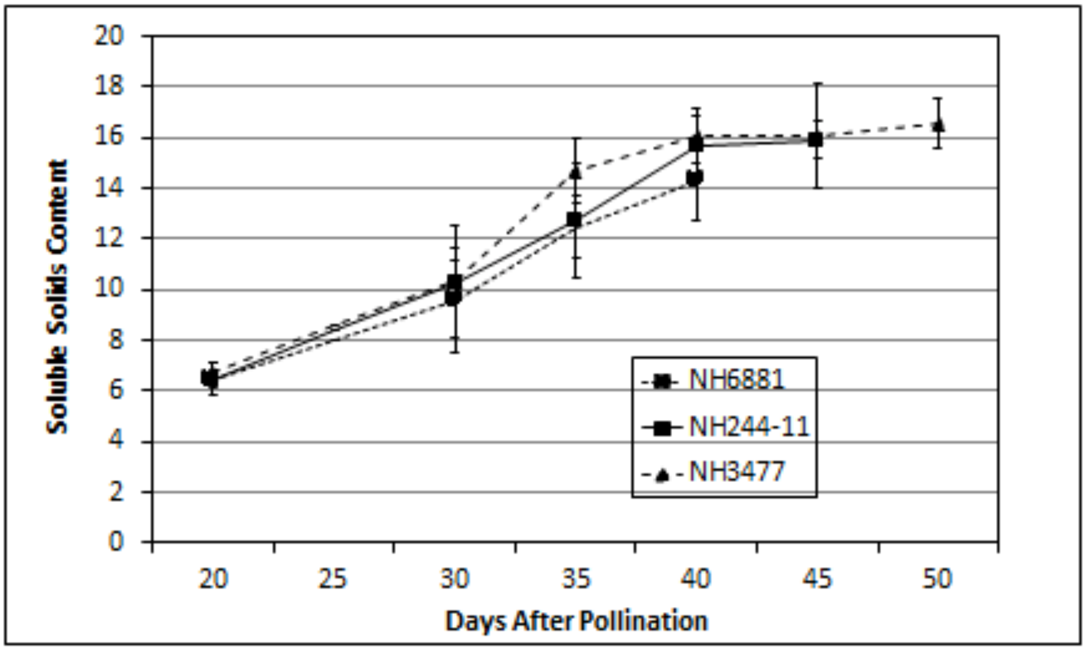


Figure 1. Accumulation of soluble solids (SS) in flesh of cantaloupe inbred parental lines and the $F_1$ hybrid (NH3477). Parental line NH6881 is a full-slip melon; whereas, NH244-11 is a LSL line. Values ± SD a represent means of 4 replications and one to four samples per replicated plot.

LSL melons, the normal ethylene-mediated climacteric ripening pattern is suppressed, and melon fruit do not fully change color and stems do not slip. However, sugars continue to accumulate in such melons sometimes up to a SSC of 16 to 18% (Figure 1). Melon aromatic properties are generally compromised in such melons, but we have developed $F_1$ hybrids in which only one of the two parents has LSL genetics, and such hybrids often have nearly full melon aromatic qualities along with higher sugar content. The trick is determining when to pick these melons. Commercially, such melons are harvested a particular number of days (or cumulated heat units) from average fruit set. We currently have some melon lines which have a marker trait (yellow flecking of the rind) for the correct harvest time, and are trying to develop acceptable varieties with this marker trait. Carotenoids, the orange pigments in cantaloupes, also accumulate over time, and if a LSL melon is picked prematurely, sugar content may have reached 11 SSC or higher, but carotenoid pigmentation will appear low, aromatic constituents barely detectible, and both eating and nutritional quality will be compromised. An additional advantage of LSL melons is providing a considerably longer harvest window along with improved shelf life.

WINTER SQUASH. Winter squash is an esteemed vegetable in some regions of the world, and is moderately popular in North America. Unfortunately, there are not adequate quality guidelines for squash harvest and variety selection in North America, so squash quality is often marginal for certain types of squash. Unlike melons, squash fruit store their carbohydrates in the form of starch not sugar. However, acceptable eating quality requires a balance of starch, for a smooth, pasty texture, and sugars, for sweetness. The period during which starch begins to be degraded into sugar varies considerably among the major groups (species) of squash and also among varieties within a species, so growers need to be well grounded in quality aspects of the varieties being grown.

Starch content is tedious to measure in squash tissue, but fortunately, the % dry matter or dry weight (DW) is positively correlated with starch content at harvest (Figure 2). Research on eating quality conducted in New Zealand and at UNH indicates that for most squash to have good eating quality, the % dry matter of the flesh, mostly in the form of starch and sugars, should be between 18 and 25%, and the soluble solids, a measure of relative sugar content, should be 11% or greater. If squash has dry matter higher than 25%, it is too dry to be acceptable for most consumers, so additional storage and a SSC higher than 11% may be needed to acquire the necessary textural properties for acceptable eating quality.

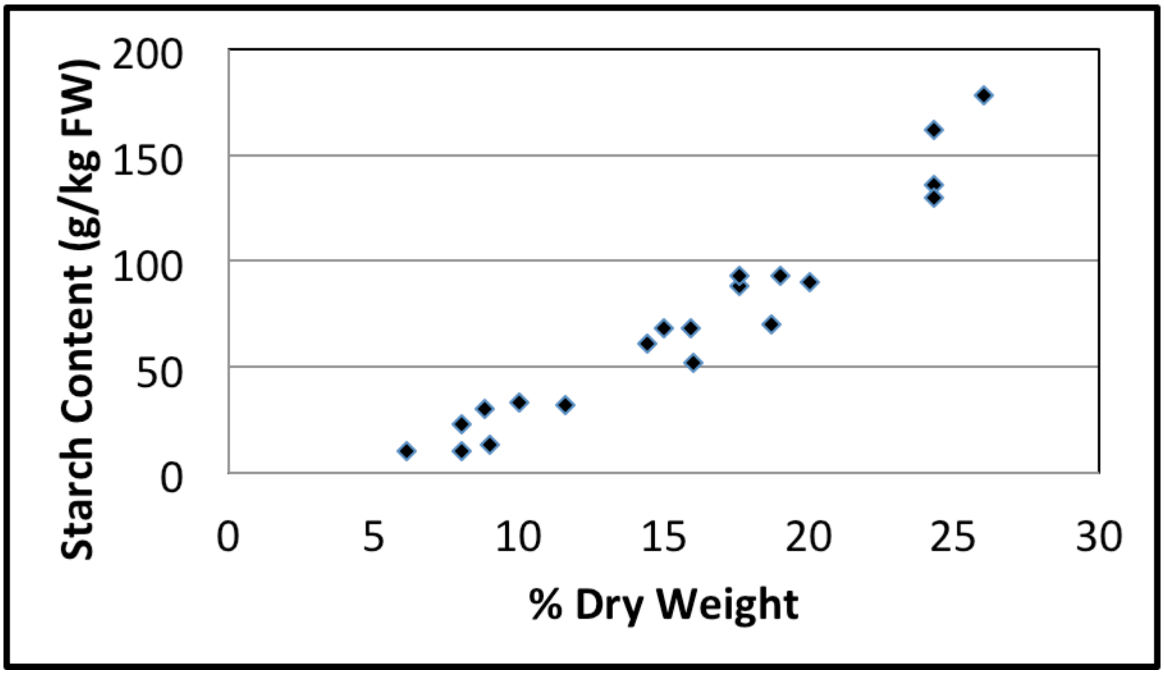


Figure 2. Relationship of starch content to dry weight in mesocarp (fleshy) tissue of winter squash fruits. Data extrapolated from Culpepper and Moon, J. Agr. Res. 71:111-136, 1945; T.G. Phillips, Plant Physiol. 21:533-541, 1946; Harvey et al., NZ J Crop & Hort. Sci. 25:341-351, 1997.

There are three major groupings of fresh market squash in North America: acorn (*Cucurbita pepo*), kabocha/buttercup (*C. maxima*) and butternut (*C. moschata*). Varieties within these species vary considerably in culinary qualities, and in turn, these qualities are affected by harvest time and post-harvest handling. In general, squash should not be harvested until about 50 days after pollination (DAP) and fruit set, and most will not have acceptable sugar levels at 50 DAP. It is difficult to determine the harvest period by color of fruit. Acorn fruit, for example, will reach full fruit size and dark green color within two to three weeks after fruit set, about 30 days before they should be harvested. Nonetheless, a large proportion of the fruit reaching supermarkets during the winter months have been picked between 20 to 30 days after fruit set as indicated by the light green to yellow color of the ground spot of the rind. We judge such squash as inedible in our cooking tests.

Most green-skinned kabocha varieties average greater than 18% DW and have excellent eating quality. Furthermore, the SSC of kabocha varieties often reaches acceptable levels by 60 to 70 days after fruit set. Kabocha squash can be harvested as early as 40 days after fruit set, and should be harvested early if the vines go down prematurely in order to prevent sunburn on fruits. However, the storage time necessary to acquire adequate sugar levels should be extended for squash harvested early. Because most kabocha varieties have a high dry matter content, the storage life (with acceptable eating quality) is longer than for the other squash groups.

Butternut is the preferred squash for many consumers. Good quality open-pollinated butternut varieties such as 'Waltham Butternut' or 'Puritan Butternut' usually will have dry matter in the 17 to 20% range, and have an acceptable texture and taste for most consumers. The downside of butternut squash is lack of sufficient sugar content when harvested. Butternut squash will usually attain a mature tan color and maximum dry matter within about 35 days after fruit set, but will have a low sugar content and poor flesh color at this stage of development. Moreover, if harvested at first color change, a longer storage period is required to attain adequate sugar content. Butternuts generally require a longer storage period than kabocha squash to attain acceptable flesh color and sugar content.

Acorn squash present an enigma for growers, especially those growing for the wholesale market. For wholesale markets, squash are evaluated on appearance only, and as such, there is little incentive for large growers to select varieties which have the best eating quality and to harvest squash when they are mature. For example, some of the major commercial cultivars have only 10 to 13% dry matter on average, and soluble solids are generally low. Such varieties, even if picked at proper maturity, do not have sufficient starch reserves to achieve acceptable sweetness and textural properties. UNH has released two varieties, 'Honey Bear' and 'Sugar Dumpling', that usually average between 18 and 20% dry matter, and have high sugar content at harvest. Starch conversion to sugar occurs early in both of these varieties, and they often attain good eating quality within 45 days after fruit set.

The optimum range of storage temperature for squash is 50 - 60 $^{o}$F. Storage temperatures lower than 50 $^{o}$F may cause chilling injury, depending upon the degree of field acclimation to cold temperatures experienced by the squash in question. For butternut squash grown in New Hampshire 40 - 60 days of storage at 60 $^{o}$F is often needed to attain sufficient soluble solids. Nonetheless, consumers purchasing butternut squash from a local market may wish to consume it immediately. Published research and our own results indicate that if squash are stored at 80 to 85 $^{o}$F for 5 or 6 days and then returned to 55 to 60 $^{o}$F temperatures, starch to sugar conversion is enhanced, allowing squash to be consumed within two to three weeks of storage. It should be kept in mind also that butternut squash in particular loose considerable fresh weight in storage.

The recommendations above for the different species of squash are meant as general guidelines, and have to be altered according to growing conditions, especially seasonal fluctuations in temperatures in September and October which can alter sugar accumulation in squash tissue. Varieties within a species differ markedly in starch content at maturity and also in timing of breakdown of starch. Only through experience and taste tasting of different varieties, or when possible, using published data, can one ascertain if and when winter squash fruits are acceptable for consumption.

**Extensive Soil Mix Studies for Greenhouse Production of Seedlings and Transplants**

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In the Cornell greenhouse program we have been studying the characteristics that make up good quality potting mixes for production of vegetable seedlings and transplants. Both conventional and organic potting mixes have been studied, but in our most recent work which we will describe here our objective was to compare different commercially or locally available organic substrates for use in seedling germination (200 plug trays with a 20 mL volume per cell) or in 4-inch container transplants (500 mL volume per pot). We have noticed an increased interest or organic production methods and locally prepared potting mixes. However as compared to conventional mixes, organic mixes can be more challenging to manage fertility, pH, and salts. Many organic potting mixes have enough fertility to support sufficient plant growth for about the first 4 weeks; these mixes seem to be preferred by organic growers to avoid the expense and labor of supplementing with additional fertility. Therefore in our trial we did not add additional fertilizers to see how the mixes would perform on their own. If necessary, additional fertility can be added by top-dressing granular materials or using liquid products. We have had success with many organic fertilizers in our trials.

The mixes trialed in this study included: Sun Gro Sunshine Natural & Organic #1 (Sun 1) and #4 (Sun 4), Sun Gro Metro-Mix Natural and Organic PX-2, a Cornell vermicompost mix (Cor), an Ithaca locally formulated mix (Ith), Vermont Compost Fort Lite (VFL) and Fort Vee (VFV), and McEnroe Organic Premium Lite (MOPL). All these mixes were acceptable for certified organic production. The Cornell vermicompost mix was, by volume, 70% peat, 35% coarse perlite and 5% vermicompost (Worm Power LLC, Avon, NY). To this we added 2.5 lbs./yd$^3$ dolomitic limestone (more can be used if the irrigation water is low in alkalinity), 5 lbs./yd$^3$ each of green sand and rock phosphate and 3.5 5 lbs./yd$^3$. The Ith mix was formulated by a local grower in Ithaca New York and was made of compost, peat, coconut coir, perlite and other aggregates and a poultry litter fertilizer. All plants were grown in a glass greenhouse at Cornell University at 70 °F average daily temperature.

In the seedling germination trial seeds tomato (‘Celebrity’ untreated) and pepper (‘Declaration’ untreated) were sown on the 200 cell trays with 3 replications per substrate treatment. After 4 weeks the experiment was terminated. Germination percentage was determined and the dry weight of 10 combined representative seedlings from a tray was measured.

For the transplant experiment plugs (well-rooted 4-5 week old seedlings) of (‘Celebrity’ untreated) and pepper (‘Declaration’ untreated) were transplanted into 4-inch containers. There were 10 replicate plants for each substrate treatment. Each week leachate samples were taken from 5 randomly selected containers from each substrate treatment and sampled for pH and EC (electrical conductivity, i.e. soluble salts - a measure of fertilizer and non-fertilizer salts). After 4 weeks the experiment was terminated. Plant height and dry weight were determined.

Seedling germination percentages and dry weights from the seedling experiment are reported in Table 2. Germination of pepper was significantly reduced and very poor from the Ith substrate. This appears to be due to high salts and immature compost in that mix. Size of pepper plants was greatest for the VFL, VFV and MOPL mixes. For tomato trial the germination percentage was greatest for Sun 1 (not significantly different from Sun 4). Ith and Cor mixes had the lowest germination percentage and these were not significantly different from VFL or MOPL. For tomato, the greatest dry weight was found with Cor, MOPL, VFV and VFL. Germination and growth of peppers seems to be negatively affected by high pH of mixes (>6.5) and high EC. Tomato has heavier fertilizer requirements and appears to be less affected by substrate pH and high ammonium in fresh compost.

For the 4-inch container transplant experiment, plant height and dry weights are reported in table 3. Many of the substrates had pH levels above the desirable range during the 4 week production period (optimum during production is 5.5-6.5). Substrate pH increased over time due to our moderately alkaline irrigation water at Cornell University. By three weeks after experiment initiation EC levels of containers had all dropped indicating that nutrients were being consumed by the plant or leached out of the substrate. For pepper, plant size was similar for the VFL, VFV, MOPL, Ith and Cor mixes. However, the Ith mix gave variable growth of plants. Plants were significantly smaller with Sun 1, Sun 2, and PX-2 mixes. For tomato, plant size was greatest for the Ith mix, followed closely by VFV, VFL, MOPL, and Cor. Again plants were significantly smaller with Sun 1, Sun 2, and PX-2 – these mixes had much lighter starter nutrient charge than the other mixes. For optimal plant growth additional organic fertility will need to be added soon after transplanting when using these mixes; while the other mixes tested appear to be suitable for pepper and tomato transplant growth in 4-inch containers at least for 4 weeks.

While we tested the same mixes for both seedling and transplant production, many growers prefer to use separate mixes for these two activities. A more finely textured mix is usually chosen for seedling germination to ensure constant water supply to the germinating seed. However decent aeration of the substrate is still necessary for both seedling and germination mixes (i.e. they should not be too water logged as roots need oxygen). When comparing the seedling to the container trials, the seedlings were more sensitive to mixes high in EC whereas the 4-inch transplants were able to take advantage of the added fertility in these high EC mixes.

To follow up the 4-inch transplant experiment we wanted to see if we could use a granular organic fertilizer, Sustane 8-4-4, to improve the fertility and plant performance of a low fertility mix (Sun 4). Sustane 8-4-4 was incorporated into the potting mix prior to transplanting pepper and tomato seedlings at a rate of 0, 5, 10, 15, and 20 lbs/yd$^3$. Sustane 8-4-4 successfully grew nice size transplants with optimal fertilizer rates of 5 lbs/yd$^3$ for pepper and 10 lbs/yd$^3$.

Organic supplied nutrients are primarily slow release and depend on biological processes to convert organically bound nutrients into a plant available form. Conditions that promote microbial activity include warm temperatures, a well-aerated root-zone and a balanced pH. Therefore nutrient release rates of a given fertilizer will vary from operation to operation based on their growing conditions. We expect that our experiences in a well-heated greenhouse (70 °F) may differ from growers if cooler temperatures are used.

Work is in progress at Cornell to compare the performance of several different granular organic fertilizers on 4-inch tomato transplants at average daily temperatures of 50, 60, and 70 °F. Our initial results indicate that these fertilizers perform well (with some minor differences) at 60 and 70 F, but plant growth and nutrient availability was really reduced at 50 °F.

Table 1. Analysis of substrates using the saturated media extract method. Preferred range is as reported by the J.R. Peters laboratory.

| | pH | Soluble Salts (mmhos/cm) | NO3-N | NH4-N | P | K | Ca | Mg | Na | Cl |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ppm | | | | | | | |
| Sun 1 | 6.6 | 0.43 | 15 | 13 | 5 | 15 | 27 | 17 | 17 | 44 |
| Sun 4 | 6.7 | 0.52 | 16 | 19 | 10 | 27 | 25 | 15 | 28 | 52 |
| PX-2 | 5.5 | 1.97 | 32 | 18 | 35 | 239 | 112 | 77 | 28 | 58 |
| Cor | 5.2 | 0.48 | 9 | 27 | 13 | 38 | 9 | 5 | 28 | 52 |
| Ith | 7.1 | 1.37 | 2 | 41 | 68 | 215 | 18 | 6 | 77 | 172 |
| VFL | 5.3 | 3.7 | 270 | 3 | 30 | 315 | 347 | 91 | 210 | 180 |
| VFF | 5.9 | 3.37 | 263 | 2 | 21 | 293 | 282 | 71 | 180 | 179 |
| MOPL | 5.7 | 3.8 | 277 | 1 | 35 | 331 | 390 | 168 | 87 | 120 |
| Preferred Range | 5.2-6.3 | 0.75-3.5 | 35-180 | 0-20 | 5-50 | 35-300 | 40-200 | 20-100 | N/A | N/A |

Table 2. Germination percentage and plant size of pepper and tomato seedlings in response to different organic substrates. Within each column, values followed by the same letter are not significantly different from each other.

| | **Germination percentage** | | **Dry weight of 10 seedlings (g)** | |
|---|---|---|---|---|
| | Pepper | Tomato | Pepper | Tomato |
| Sun 1 | 91% A | 90% A | 0.10 A | 0.33 AB |
| Sun 4 | 73 A | 85 A | 0.17 A | 0.19 B |
| Cor | 77 A | 60 D | 0.40 A | 0.69 A |
| Ith | 21 B | 46 D | 0.15 A | 0.60 AB |
| VFL | 87 A | 72 CD | 0.35 A | 0.70 A |
| VFV | 92 A | 63 BC | 0.33 A | 0.77 A |
| MOPL | 71 A | 72 CD | 0.27 A | 0.75 A |

Table 3. Plant height and dry weight of pepper and tomato transplants grown in 4-inch containers in response to different organic substrates. Within each column, values followed by the same letter are not significantly different from each other.

| | **Plant height (cm)** | | **Plant dry weight (g)** | |
|---|---|---|---|---|
| | Pepper | Tomato | Pepper | Tomato |
| Sun 1 | 14.6 C | 22.3 B | 0.60 B | 1.63 D |
| Sun 4 | 14.6 C | 22.5 B | 0.59 B | 1.95 D |
| PX-2 | 16.0 C | 24.5 B | 0.72 B | 2.57 D |
| Cor | 20.3 B | 31.6 A | 2.22 AB | 6.76 C |
| Ith | 22.1 AB | 31.8 A | 5.28 A | 9.76 A |
| VFL | 24.8 A | 32.1 A | 2.51 AB | 8.21 B |
| VFV | 19.4 B | 33.2 A | 2.12 AB | 7.88 BC |
| MOPL | 21.6 B | 32.5 A | 2.48 AB | 8.48 AB |

**From Greenhouse to Field with Quality Transplants**

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**Overview of Sisters Hill Farm.**

Sisters Hill Farm, established in 1999, is a CSA in the Mid Hudson Valley of New York. We grow vegetables for 230 full weekly shares for a 24-week season. Each year we harvest somewhere between 70,000 and 90,000 pounds of the highest quality organic vegetables on about 5 acres of growing beds spread amongst 3 fields (with no double cropping).

We grow all of our own transplants with the exception of onions. Growing quality transplants is essential to our farms success since the quality of our produce is what sets us apart from other farms and keeps members coming back year after year. Each year we grow approximately 55,000 transplants in a 30x48 greenhouse.

**Description of our Greenhouse**

The house is a gothic style, meaning it has a pointed roof to help it shed snow. I built the house from scratch in 1999, bending the pipe to shape on a homemade jig on the floor of the barn. I utilized a come-along to give me enough mechanical advantage to bend the 1.9" OD pipe by hand. The end-walls and doors are custom built to allow a very large opening at either end of the house. Each door is 10 feet wide by 8 feet tall. These large doors add a great deal of versatility to the house, allowing entire benches of transplants to be rolled out for hardening off. They also allow us to drive a tractor with forks and a bulk bin straight into the greenhouse and position it ergonomically so we can unload both onions and winter squash onto our greenhouse benches to cure or dry. Above each door is a 10 foot wide cantilevered vent that extends all the way to the peak. It is controlled by a rope and a couple of pulleys and can be adjusted to allow varying amounts of fresh air to enter the greenhouse. It is very effective at cooling a house that is only 48 feet wide.

I keep the house on the cool side, maintaining a nighttime temperature of 55 to 60 degrees. This is in an effort to save propane--for global warming reasons more so than financial. For the crops that need supplemental heat to germinate quickly I use an electric heat mat. I get them from Nolts Produce Supply in Pennsylvania. They come in widths of 11 inches by 10 feet. I use a piece of xps foam insulation under the mat to make sure all of the heat is going up into the flat. Another thing that greatly helps with saving fuel is what I call my "heat saver." It's simply a remnant of greenhouse plastic that is cut to fit over any one of my arches from the greenhouse frame. I've souped it up a bit and made it more user friendly with the addition of some special clips that secure the plastic to the frame and a quick opening and closing system—basically a 2x6 ripped down the middle with a tongue on one side that fits into a dado on the other. There is a door hinge zip-tied to the peak of the house and screwed to the end of each board. This hinge supports the assembly as you fold it over to either side of the house to open it up for better airflow each morning. All told it only takes a few seconds each day to manage the "heat saver" and it can greatly change the heating demands during the coldest nights, especially in the early spring when you may only have a few benches filled with tomatoes and onions. Why heat the entire greenhouse for just those crops?

**How Much Greenhouse Do I Need?**

I think it's important to keep the greenhouse part of your operation in perspective. For me, as a CSA grower, managing the greenhouse to produce our transplants is a very small percentage of the overall work on the farm. It is certainly important to develop farm wide systems that work and are efficient, but as a farm consultant I often see new growers putting too much money into the greenhouse early in the development of the farm. If your farm's marketing focus will be on bedding plants, or selling transplants, then perhaps high tech innovations such as ebb and flow, bottom heat, or single aisle systems may be worth the investment. If, however, you will be marketing vegetables through a farmers' market or CSA, a much better investment would be to buy a walk-in cooler—it will pay for itself in labor savings and improved crop quality almost immediately. The same is true of greenhouse tools like vacuum seeders. When considering a tool such as a vacuum seeder, closely evaluate what your labor costs are and measure how much placing seeds in trays is actually costing you.

The workforce at Sisters Hill Farm consists of 3 apprentices and me; they love the change of atmosphere that greenhouse seeding, watering, and thinning provides. Plus it's great to be able to save up a little greenhouse seeding for those rainy spring days, when the soil is too saturated to do much outside.

**The Keys to Growing Quality Transplants**

1. Good potting mix. We buy our potting mix from McEnroe Organic Farm. We've had good success with it for 15 years
2. Good flats or plug trays. We use Winstrip 128 cell plug trays for most of our transplants. We also use some 20-row flats for seeds that we like to germinate with some bottom heat and then pot on to larger cells. And we use a few 72's, 50's and even some 4" pots for our earliest tomatoes, peppers and eggplants. The advantage of the Winstrip trays is that they are very durable and so will last for many years, they foster good "air pruned" root growth, and they don't need a carrier flat.
3. Care when watering. I teach my apprentices how to carefully asses the state of transplants before they begin watering. When trying to figure out when to water and how much to apply, they must be able to analyze out how dry things are, how much drying out is desired between waterings, as well as the impact of the weather. To do this I encourage them to walk around the house and get a sense of things by pulling out plants they suspect might be too dry, lifting the trays to compare relative weights, looking at the bottom of the cells and other simple tests. Watering will then consist of up to 3 or more passes depending on how dry things are. If the cells have dried unevenly, they may first do a spot watering of

the driest cells to break that surface tension that sometimes develops with organic potting mix. Next they will do a pass over every bench moving the spray pattern in one direction. Then they will start at the same point and do a third pass going perpendicular to the last pass. By approaching it in this way, they make sure that no spot has been missed, and the water has had time to fully saturate the media, (but not so saturated that there is a lot of water dripping through the cells and leaching nutrients out of the potting mix.) When I show them how to water I teach them to "dance" with the hose held high and their arm extended, utilizing their larger muscle groups, so that they can maintain an even, metronome-like speed and a consistent angle of approach over the flats. Each apprentice is in charge of watering for a full week at a time.

**4.** Good air circulation. I designed the house tall, wide and short (30x 48') so that when I open my doors and gable end vents the house will cool quickly without the need for mechanical ventilation. Since the vents extend all the way to the roof, I have nearly the same cooling potential as a ridge vent at a fraction of the cost. There are two HAF fans that help create good airflow and prevent damping off during periods of extended overcast wet weather. They are turned on as needed.

**5.** An easy transition to the field. I harden the plants off not by restricting water, but by moving them out of the greenhouse into the full sun and wind gradually. The first day may only be an hour or two, the second maybe half the day, and the third perhaps all day, bringing them in at night each time. This process can be easily be done by one person in a matter of minutes because my benches are built with wheels on one end. Each bench holds 30 flats so one worker can move over 10,000 plants in or out of the greenhouse in less than 2 minutes. The rolling benches have dual usage around the farm; they can be used as mobile wash stations as well. Since we have irrigation boxes in the ground in all of our fields, we simply roll a bench out and set up a wash tank right at the end of the field from which we are picking. We are able to keep our small crew together more often this way, which keeps morale high and the speed up. The fact that we hydro-cool the produce so quickly keeps the quality high as well.

**6.** Precise planting and watering in immediately. We place transplants in the soil by hand. We own a very sophisticated transplanter, but prefer to place them by hand because we can get the spacing more precise and plant them more carefully without idling a noisy tractor down the bed. We are also nearly as fast this way. We can plant over 15,000 plants a day by hand with great precision. But most days we have far fewer plants to put in so the task is never that onerous. This is the quintessential task to new would be farmers; sinking your hands in the dirt and placing a young plant just feels right to them. Joy is an important consideration. I mark the bed with a custom row marker that imprints a grid on the soil; it's mounted under a cub tractor. One person drops plants at the appropriate spacing on the grid and the others kneel in the center of the bed placing plants as they progress up the bed. After all the plants are in we usually water them in with overhead irrigation. That's a quick overview of our transplant production at Sisters Hill Farm.

**Greenhouse Transplants through Quality Seeds and Controlling Diseases**

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When a plant disease starts to develop in the greenhouse, the result can be dead plants, since young plants are very vulnerable, or a season-long battle in the field after transplanting. In addition to the importance of starting with healthy transplants, disease management steps such as sanitation and environment modification can be easier to implement in the greenhouse compared to the field, and more successful. Damping-off and gray mold are the most common diseases of greenhouse transplants.

*Pathogen-free seed.* Ensuring seed is not a source of pathogens causing diseases is an important first step in management. Some pathogens can be on or in seed. Fortunately, not all are capable of becoming associated with seed, but some important pathogens can. Seed-borne fungi include pathogens causing Septoria leaf spot of tomato and Alternaria leaf spot of crucifers. Diseases caused by seed-borne bacterial pathogens include black rot of crucifers, bacterial leaf spot of pepper, and bacterial canker of tomato. Contaminated seed can be an important first source of a pathogen on a farm or even a larger area (most notable example is the new downy mildew of basil in the USA). Additionally, a severe disease outbreak can result when a pathogen is present at the start of plant growth. Pathogens able to get inside seed are especially difficult to manage because a surface treatment won't affect them. Only heat treatment can get in to these pathogens.

Inquire about the seed's history before purchase. What measures were taken to minimize the opportunity for seed to become contaminated during production. Producing seed where seed-borne pathogens do not occur and/or where environmental conditions are not favorable, such as in a greenhouse, are ways to obtain clean seed. Also ask if the seed was tested and/or treated for seed-borne pathogens. This information is often on the seed package.

If you save your own seed or buy from a small producer, hot-water treatment may well be worthwhile. The procedure is suitable for small-seeded vegetables including tomato, pepper, brassicas, and lettuce. Treatment temperature and time are critical to achieve success without adversely affecting seed. Information about how to treat seed including specifics for several crops is at http://vegetablemdonline.ppath.cornell.edu/NewsArticles/HotWaterSeedTreatment.html. Companies that test seed include STA Laboratories (www.eurofinsus.com/stalabs/). This is a destructive procedure typically done with a minimum of 10,000 seed, but it can be done with less.

*Sanitation*. To manage pathogens that may be present from the previous season, thoroughly clean and then disinfect planting containers and greenhouse surfaces before beginning to grow transplants.

During production of transplants implement practices to minimize the opportunity for pathogens to be brought into the greenhouse. Clean boots of soil. In greenhouses with natural floors, cover the ground with landscape cloth to form a barrier over the soil.

Use sterilized potting mix.

*Environment modifications to make the greenhouse less favorable for disease development*. Most fungal and bacterial pathogens affecting foliage require a certain amount of time with free moisture (wetness) in order to infect. High humidity is sufficient for others, including those causing downy mildews, gray mold, and late blight. Minimize leaf wetness and humidity by using bottom watering, wide plant spacing, fans, ridge venting, lights, and also open doors during warm mornings and avoid overwatering. Keep plants on benches. Adjust water amount based on conditions and plant needs so that the seeding mix does not stay wet for long periods and is dry the next day. Check greenhouse roof for dripping from condensation in morning or from rain. Do not locate plants where water drips if the reason can't be rectified.

Some pathogens, including those causing tomato bacterial spot and Septoria leaf spot, are primarily dispersed by splashing water. This is another reason to use bottom watering. When this is not feasible, water plants after any guttation has dried and when there will be time for leaves to try before night time.

*Manage insects that can vector plant pathogens*. These include thrips, aphids, and fungal gnats. Clean up spilt potting mix as this can provide habitat for fungal gnat larvae.

*Manage weeds and do not grow ornamental plants in the same greenhouse as vegetable transplants*. These plants can harbor pathogens, notably viruses, as well as insects that can vector them.

*Routinely inspect plants for symptoms*. Obtain help with diagnosis when at all unsure.

*Dispose of dead and diseased plants away from the greenhouse*.

*Do not brush tomato plants*. Mechanically brushing the top of tomato plants results in plants that are shorter with greater stem and petiole strength; however, it also can move bacterial pathogens and cause wounds (including broken leaf hairs) that enable bacterial pathogens to infect.

*Apply fungicides and/or biological control products*. This can be a warranted addition to the management program with diseases not effectively controlled with cultural practices in the past or at first symptom. Note that some pathogens, including those causing bacterial spot and canker in tomato, can be present, multiplying, and spreading without causing symptoms. See list of products at end of this write-up.

**Managing Botrytis Gray Mold in Greenhouse Vegetable Transplants**. This disease is hard to avoid because the pathogen has a wide host range and produces an abundance of wind-dispersed spores. Keeping humidity below 90% is key. Also remove dead plant tissue because the pathogen usually first develops on dead tissue then invades adjacent living tissue.

**Managing Damping-off in Greenhouse Vegetable Transplants**. Damping-off can be very destructive in the greenhouse due to close plant spacing. Fortunately, ability to prevent the pathogen from being present and to avoid favorable conditions in the greenhouse means it is easier to manage damping-off there than in the field. Use good sanitation: clean and disinfect everything before seeding. Pathogens that cause damping-off can be in soil around the greenhouse and unsterilized seeding mix, and they can survive on trays and pots. Clean shoes before entering the greenhouse. Keep the hose end off the ground. Select sterilized seeding mix with good drainage. There are several biological control products that can be added to seeding mix when damping-off has been a problem in previous seasons (see list at end). While watering plants, avoid the possibility of splash moving soil to plants. Be careful not to overwater, especially during periods of cloudy, rainy conditions. Adjust water amount based on conditions and plant needs so that the seeding mix does not stay wet for long periods and is dry the next day. Water early in the day and provide air flow to reduce humidity so that soil will dry quickly. Provide good plant spacing.

Where seedlings are dying or growing poorly (wilting, stunted), first confirm that it is damping-off by looking at the roots of affected plants. Roots of diseased plants usually have brown tissue and the outer layer may be partly rotted off. Seedlings can collapse due to other causes, including excessive fertilization, high levels of soluble salts, excessive heat or cold, excessive or insufficient soil moisture, bleach residue on trays, and severe infestation of fungal gnat larvae or other insects. Roots of these plants will be a healthy white to tan color. If damping-off is likely the cause, it is important to separate trays with diseased seedlings from those that are not affected. Trays with affected seedlings should be discarded. Fungi that cause damping-off can be spread by splashing water. Fungal gnats can also move some fungi. The most common pathogen causing damping-off, *Pythium*, develops best under wet soil conditions. It is also important not to underwater as dry conditions are favorable for *Rhizoctonia*, another damping-off pathogen, and will stress seedlings, which can increase susceptibility. Another important step in management is to try to determine the source of the pathogen when damping-off occurs so that it can be controlled to minimize the chance of this disease occurring again next year. Damping-off pathogens exist in soil. Look for sources of soil in and around the greenhouse that could have gotten into seeding trays such as by splashing water. Dispose of trays that held diseased plants.

**Biofungicides for damping-off and other diseases**. There are products that can be applied to potting mix from before seeding to after plants are established. They are best used preventively, and where damping-off has previously occurred despite cultural controls. Most are labeled for the major pathogens causing damping-off, plus others. Bio-Tam (*Trichoderma asperellum* strain ICC 012 and *Trichoderma gamsii* strain ICC 080) can be applied as a greenhouse drench to transplant trays. A concentrated solution may be prepared 24 to 36 hours prior to treatment to initiate conidial germination which will result in faster soil colonization. Combine 1 oz of BIO-TAM for every 10 fl oz of water. Mix this solution periodically to promote the germination of conidia. Dilute to 2.5 to 7.5 oz per 100 gallons water before applying. Typical application rate is 1 pint of solution per square foot of growing medium that is 4 inches deep. RootShield Granules (*Trichoderma harzianum* Rifai strain KRL-AG2) can be incorporated into mix before seeding. Serenade Soil (*Bacillus subtilis* strain QST 713) is a new formulation of Serenade for soil application. This bacterium colonizes roots and produces compounds that affect pathogens directly and trigger metabolic pathways to activate the plant's natural defenses and modulate growth. Actinovate (*Streptomyces lydicus* WYEC 108) and also Double Nickel 55 (*Bacillus* *amyloliquefaciens* strain D747) can also be applied as a soil drench plus they can be applied to foliage for several diseases. Regalia (extract of *Reynoutria sachalinensis*), previously labeled only for foliar diseases, is now labeled to permit application as a soil drench as well as in transplant water. It boosts the plants' natural defense mechanisms against certain fungal and bacterial diseases. Most biofungicides are approved for organic production.

**Conventional fungicides that can be applied in the greenhouse**. Start at or before first symptoms. Ensure disease is correctly identified. Apply regularly (e.g. weekly) maximizing coverage. Check label for restrictions on use on transplants and on greenhouse use. Some products are permitted for use only outdoors. These include Bravo, Cabrio, Endura, Flint, Forum, Quadris, Presidio, and Ranman (except for basil).

Some fungicides labeled for use in greenhouses include Agri-mycin 17, Armicarb, Botran, Contans, Copper (some formulations), Decree, Dithane, JMS Stylet-Oil, Kaligreen, MilStop, Oxidate, Ranman (see below), Previcur Flex (see below), Scala, Sonata, and Bio-Tam. Fungicides with no restrictive statement about greenhouse use: Curzate, Gavel, Penncozeb, Tanos, Revus, Revus Top, Switch (except small-fruited tomatoes) and phosphorous acid fungicides (ProPhyt, Phostrol, etc.). The antibiotic Agri-mycin is labeled for controlling bacterial spot in tomato and pepper seedlings. It can be applied as frequently as every 4-5 days beginning when first true leaves appear.

Previcur Flex (propamocarb hydrochloride, FRAC Code 28), a conventional fungicide with targeted activity for some pathogens causing damping-off and root rot, *Pythium* and *Phytophthora*, is labeled for use in the greenhouse to manage damping-off in tomato, leaf lettuce, cucurbits, and peppers. It can be applied before seeding and/or after emergence, and through drip irrigation. Note the use directions state not to apply to dry growing mix, not to apply to plants when sunlight will be intense afterwards (evening application recommended), and not to mix with other products.

Ranman (cyazofamid, FRAC Code 21) is another fungicide with targeted activity for *Pythium* and *Phytophthora*. It is labeled for use in the greenhouse to manage damping-off on tomato. It can be applied once to the seedling tray at the time of planting or at any time thereafter up until 1 week before transplanting. Apply the fungicide solution as a drench to thoroughly wet the growing medium. This results in the use of approximately 1 pint of solution per square foot if the growing medium is 4 inches deep. Product rate is 0.887 ml per gal. Disposable plastic syringes that do not use a needle are available to order on the internet for measuring small quantities. They come in several sizes including 1, 3, and 5 ml maximum capacity, and have gradations for measuring smaller amounts.

*Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Before purchase, make sure product is registered in your state and approved by your certifier for organic production. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.*

# Transplants for Profit

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Checkerberry Farm is located in the Maine Central Highlands south of Moosehead Lake. We are a MOFGA certified organic farm. Our main focus is wholesale vegetables. We produce seedlings for FEDCO Seeds, other farms and our own field production.

By starting seedlings in a greenhouse environment we have relative control over germination and growth. We can transplant seedlings out when conditions are agreeable. While in the greenhouse actions such as potting up, singulating, grafting and tending becomes efficient.

We have a production greenhouse which has heating and venting systems and rolling benches to maximize production area. We have heatable high tunnels to handle the overflow of seedings. For example in March the onions can migrate into a cooler tunnel. This makes more room in the production greenhouse for the seedlings requiring more heat.

The field equipment that we use for planting transplants out in the field include a bed shaper, a mulch layer, a water wheel transplanter and a three unit 22C Mechanical Transplanter.

By using this approach we can have a much earlier start for both one shot crops like onions and celeriac and sequential crops like broccoli and lettuce. Other benefits include scheduling, a uniform stand and there's no thinning involved.

We found that this method makes the best use of our labor costs and benefits the overall efficiency of the farm.

**What Makes a Great Transplant: How to Achieve It & Mistakes to Avoid**

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What makes a great transplant:

Proper maturity at transplanting
Free of disease and pests
Not root-bound
Hardened-off, but not stressed

How to achieve it:

Proper timing of seeding, crop scheduling
Sanitation and disease control
Proper plug size
Proper soil mix, soil pH, watering, nutrition

In theory, raising transplants is not very difficult. Unfortunately, things can go wrong. Some common problems include:

**Seeding too soon**
You will have to use a lot of extra heat when planting in late winter. Young seedlings may suffer from damping-off on cold days without a lot of sunlight, and the surviving seedlings may end up "leggy".

**Germination Chamber**
Germination chambers can help speed up germination, but make sure to remove the trays from the chamber as soon as the first seedlings emerge. The emerging seedlings need to be exposed to light as soon as they emerge from the soil, or the seedlings will stretch and be floppy and twisted.

**Soil pH**
Many problems with poor performance in the plug trays are related to poor soil pH. A simple soil pH meter will be very useful when trying to determine why plants have poor color, uneven growth, or "failure to thrive".

**Water pH and temperature**
Nothing says "good morning!" like an ice-cold shower! Your young vegetable plants will love you for tempering the irrigation water. Also, check the pH and bicarbonate content of irrigation water, and inject acid if needed to balance alkaline water.
When watering in the afternoon, you will notice that the water in the hose can get pretty hot. Run some water through the hose before scalding your germinating seeds…..

**Nutrition**
Together with poor soil pH, plant nutrition is responsible for a large number of problems in transplant production. Check fertilizer concentration in your irrigation water and stock solutions, and make sure that the injector is calibrated correctly. Use a conductivity meter to check your work.

**Plug size**
Smaller plugs allow you to produce more plants in the same space. Transplants produced in smaller plugs will be ready earlier (but smaller…), will need to be watered multiple times each day, will become root-bound earlier, and will not allow you to hold the plants in good quality if you cannot get into the field to transplant on time….

**Disease and Pest Control**
Plants in a protected greenhouse environment will be more "tender" than plants growing outside. This means that these plants are more sensitive to damage from chemical pesticide applications – make sure to follow label directions carefully, and do not over-dose!

**Sanitation**
Bacterial diseases are very easily spread from plant to plant in a high-density greenhouse setting (Black Rot in Brassicas, Canker in tomatoes, etc.) Start with clean seed (seed should be tested!), and start with clean trays, benches, etc.

**Technology**
Technology can fail. Heaters break, fans seize up, injectors plug. Check your equipment regularly.

**Hardening off**
Like cold showers, hardening off is over-rated. Give your young plants a chance to get used to the outside weather, wind, and sun. Just don't bake them and let them die from thirst….

You will produce a good crop with actively growing, young and healthy transplants – planted in a nice and welcoming soil.

I wish you great success!

## Varieties- Tried and True/New and Promising

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One of the most critical aspects of establishing a healthy berry planting, along with proper site planning, is obtaining high quality planting stock that has a vigorous root system and is free from disease and insect pests. The plants should be obtained from a reputable nursery that participates in a certification program to ensure plants are free from diseases such as viruses and root rots. Plants should be ordered well in advance of planting to ensure an adequate supply of the desired varieties.

Strawberries are one of the most variable and temperamental of the fruit crops and the choice of varieties is extensive because individual varieties are often adapted to a relatively small growing region. The most commonly grown varieties in the northeastern U.S. are short-day (June-bearing) types and new varieties are constantly being developed. Newer day-neutral varieties are gaining popularity for potential offseason production in plasticulture systems. Most varieties have some weaknesses so growers are advised to try new ones on a limited scale to determine how they will perform in each situation.

### Variety Descriptions

#### *Early Season*
**AC Wendy** (Nova Scotia) produces large blocky/conic fruit with good quality and flavor and higher yields than most early season varieties. Ripening tends to be uneven leaving white tips and/or shoulders especially when temperatures are high. Establishment of new plantings has been uneven. It is susceptible to leaf spot late in the season.

**Annapolis** (Nova Scotia) is a large fruited early season variety. The fruit is pale red and soft with good flavor and can have high yield. It is susceptible to powdery mildew and *Verticillium* wilt.

**Daroyal** (France/Spain) produces large, wedge to conic shaped dark red fruit with dark red flesh in the Honeoye season. The plants are vigorous and establish well.

**Earliglow** (USDA, MD) is still considered the best tasting berry around. Primary berries are large and attractive and are suitable for retail or wholesale. Berry weight drops off quickly after the primary berries and yields are relatively low. It is susceptible to powdery mildew after harvest.

**Honeoye** (Cornell University, NY) produces an abundance of large, attractive, firm, berries that are suitable for all markets. Closer to an early mid-season, the look of this berry sells it, but taste is the major drawback as it can be tart and can develop disagreeable aftertastes when over ripe or in heavy soils. It is susceptible to red stele disease but is manageable.

**L'Amour** (Cornell) produces very attractive heart shaped berries with bright red color. The fruit has a very good, aromatic flavor with good eating quality. The plants are vigorous and disease resistant and remain productive for many years. The fruit is larger than most early season varieties.

***Mid Season***

**Chandle**r (University of California) is a standard southern variety grown for wholesale markets in plasticulture with high yields in the Carolinas. It can have problems north of the mid-Atlantic region due to lack of strong winter hardiness. Chandler is also susceptible to anthracnose fruit rot.

**Darselect** (France) is a large fruited, high yielding variety. The berries are attractive and bright red with a long conical shape. The flavor is very good. However, it tends to be soft. It is susceptible to powdery mildew, which can be a problem in areas with morning fog.

**Jewel** (Cornell University, NY) continues to be the favorite in the northeast for this season. The high quality berries are large and attractive with good flavor. Yields are moderate to high. On a good site, it's hard to beat. It is susceptible to red stele and can have vigor problems in poor or cold sites.

***Late Season***

**AC Valley Sunset** (Nova Scotia) produces large conic fruit into the late season. The conic fruit tends to be a bit rough in shape but still attractive. As with al late season varieties, tarnished plant bug can become a problem and extra care at renovation is warranted.

**Allstar** (USDA, MD) is good yielding, high quality variety with good flavor. Unfortunately, the color is pale to orangish and is can be unacceptable to an uninformed consumer.

**Cabot** (Nova Scotia) produces impressive berries. Average fruit weight is larger than any variety currently available. Primary berries oftentop 40g. The color can be pale throughout the berry and primary berries are often irregular in shape. Yields are very high. It is resistant to red stele but is susceptible to virus infection and cyclamen mites.

**Clancy** (Cornell University, NY) produces round conical shaped fruit with darker red color and good flavor. The flesh is very firm with good texture and eating quality. The fruiting laterals are strong and stiff, keeping the fruit off the ground until they reach full size. It is resistant to red stele root rot.

**Donna** (France/Spain) produces medium large fruit that is very uniform. The fruit is darker than Darselect with similar quality but somewhat soft. The flavor can be bland.

**Ovation** (USDA, MD) is extremely late. It doesn't flower until after most others are past their peak bloom. The plant is extremely vigorous and produces multiple crowns. Fruit quality is average but there is little to compare it to in its season. Yields are moderate.

**Record** (Italy) produces large fruit in the late season with good yields reported. The color is darker than Idea, which it replaced, but is still considered light to slightly orange, similar to Allstar.

**Seneca** (Cornell University, NY) is probably the firmest short-day variety available for the east. The fruit is large, blocky and bright red with a strong flavor. It doe not runner heavily and can be adapted to plasticulture.

**Winona** (University of Minnesota) has very large berries and average yields but can not compete with Jewel for fruit appearance. It has good vigor though and might be useful where Jewel does poorly.

***Day Neutral***

**Albion** (University of California-Davis) produces long conic shaped berries with good flavor and large size. The color is bright red with little interior color. It can produce a good second crop in late summer and into the fall, especially with low or high tunnels are used to protect the plants. It is very susceptible to fruit, leaf and root diseases.

**Evie 2** (U.K.) produces medium large beet-shaped fruit that are bright red with a pale interior. Fruit production in the summer is high but in the fall has been moderate. It is very susceptible to fruit, leaf and root diseases.

**Monterey** (University of California-Davis) produces large attractive berries with a bright red color. The fruit is extremely firm, typical of many UC varieties with a large calyx. It produces a good second crop by late July and into the fall, especially with low or high tunnels are used to protect the plants. It is very susceptible to fruit, leaf and root diseases.

**San Andreas** (University of California-Davis) produces large attractive berries with a bright red color. The fruit is moderately firm with a good texture. It tends to cap easily if not picked carefully. It can produce a good second crop in late summer and into the fall, especially with low or high tunnels to protect the plants. It is very susceptible to fruit, leaf and root diseases.

**Seascape** (University of California) produces large, attractive darker red fruit. It is moderately firm with good flavor. It can produce a good second crop in late summer and into the fall, especially with low or high tunnels to protect the plants. It is susceptible to fruit, leaf and root diseases but less so than other UC varieties.

**Tribute** and **Tristar** (USDA, MD) have been the standard day neutral varieties for the northeast for the last 20 years. They are disease resistant, vigorous, and runner enough for matted row production. Both are relatively small fruited and low yielding but off-season fruit may pay off. Of the two, Tribute has better size and Tristar has better flavor.

**Strawberry Insects and Diseases – What to be ready for and IPM practices**

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There are several important insect pests and diseases of strawberries that growers must be aware of in New England. Some are long established and others are new introductions. In order to manage them effectively, growers will need a good understanding of the life and growth cycles of the plants, pests, and beneficial organisms and how to correctly identify the cause of problems that may occur. For this growers will need a few tools and resources:

| Item: | Why you need it: |
|---|---|
| • A good magnifier or hand lens | For better viewing of small details |
| • A flat white beating tray or plate | For sampling TPB and other pests |
| • A sweep net | For sampling flying insects in the canopy |
| • Some ziplock bags and small vials to collect specimens in | To collect examples from the field for closer examination or sending to Diagnostic Lab |
| • Map(s) of the field(s) | To record findings, special conditions, soil changes, hot spots, etc. |
| • A weather station or access to weather data | To employ the use of weather based models for management decisions |
| • A good ID guide | To help correctly identify findings in the field |
| • A copy of IPM scouting procedures and thresholds for your crop | To know the best way to sample for each pest and know when treatment is needed (action threshold) |
| • A current copy of the New England Small Fruit Management Guide, Cornell Organic Strawberry Production Guide, or similar guide for your area | To assist in deciding what action to take if a treatment is needed |
| • A good record keeping system | To help evaluate successes and failures from year to year |

**Key Strawberry Insect Pests and Diseases**

Below are some short descriptions of the key insect pests and diseases that will be covered in this talk. The information presented here is basic and more detail will be provided in the talk. Also, some good web based resources are listed at the end of this paper.

## Insects

***Tarnished Plant Bug***

**ID/Life Cycle**: The tarnished plant bug (TPB) is a small bronze colored insect with a triangular marking on its back. It is a 'true bug' with piercing/sucking mouthparts. The immature stage, or nymph, is smaller and bright green, resembling an aphid, but much more active. TPB is a ubiquitous feeder with a wide host range.

Tarnished plant bug overwinters in protected areas such as leaf litter, plant debris, hedge rows and brush piles. Adults become active and lay eggs in grasses, broadleaf weeds, and in strawberries in early to mid-May. The eggs hatch to nymphs in 7-10 days depending on the temperature. The nymphs may be present on the plants as early as the second week of May. The first observation of nymphs usually occurs during full-bloom period of mid-season flowering cultivars. Nymphs undergo 5 stages of development. There are several generations per year.

**Damage**: This is the most significant insect pest in strawberries. Both adults and nymphs feed on the developing flowers and fruit, sucking out plant juices with straw-like mouth-parts. This results in deformed fruit: typically "cat-faced" berries, also called nubbins or button berries. Such fruit are generally unmarketable. Damage can cause significant crop loss.

***Monitoring and Management:*** Monitor for TPB nymphs by shaking flower trusses over a white surface and counting the number of nymphs present. At each of five sites per field, shake 10 flower clusters over a white pan or paper to dislodge the nymphs. The action threshold for nymphs is when 1 out of 4 flower clusters is infested with at least 1 TPB nymph. At this level, control measures can be applied to maintain quality and yield before too much damage occurs.

***Strawberry Bud Weevil/Clipper***

**ID/Life Cycle**: This insect is a very small beetle with a copper-colored body and a black head with a long snout.

Strawberry bud weevils overwinter as adults in protected areas such as fence lines, hedgerows and woods. They migrate into the strawberry field from overwintering sites in early spring when flower buds are visible and beginning to extend from the strawberry crown. After mating, the female deposits an egg inside an unopened flower bud and partially cuts off the blossom stalk. This is where the common name the "Clipper Weevil" comes from. The damaged bud will not open. It wilts, turns brown and dries up, providing a place for the egg and larva to develop. New adults emerge in mid-summer, feed on pollen from flowers and weeds until the fall, and seek out overwintering sites. They have only one generation per year. A resident population (one that becomes established inside the strawberry field) may develop in plantings older than 3 years.

**Damage**: Damage is cause by the clipping of flower buds, which then fail to develop as fruit. High levels of injury can lead to significant yield impact. However, some varieties seem to be able to compensate for lost buds by producing larger berries from remaining buds, a thinning effect. Infestations tend to be concentrated near the hedgerows, woods, and stonewalls that border strawberry fields.

***Monitoring and Management:*** Early detection of clipper activity is important. Watch for clipper adults and damage when flower buds start coming out of the crown and when temperatures approach 65˚F. Check a 2 ft section of row at each of 5 sites per field. Sampling should be most intensive along field edges near woods or hedgerows or where weeds are heavy. The action threshold is 13 clipped buds per 2 ft of strawberry row.

If king blossoms are open, look for shot-holes in flower petals caused by females searching for pollen to feed on. This is an easy symptom to see.

***Two-Spotted Spider Mite***

**ID/Life Cycle**: Two-spotted spider mites are tiny arthropods that live on the underside of strawberry leaves. Females are slightly larger than males and both have two dark patches (spots) on their backs. They are best viewed with a hand lens as they are difficult to see with the naked eye and form colonies as the numbers build up.

They overwinter in cracks and crevices on the strawberry crowns or in the surrounding duff around the plants. There are many generations per year. Both adult and immature mites feed on plant sap and have a wide host range, feeding on many species of plants.

**Damage**: Under heavy infestations, mite feeding destroys leaf chlorophyll and causes leaves to have yellowish or whitish speckles, then an overall bronze color. Leaves will be covered in fine webbing. Yield reductions may occur from repeated heavy infestations. The most serious reductions in yield may result from early season feeding, so scouting for overwintered mites in early May is especially important.

***Monitoring and Management:*** Mites should be monitored weekly by sampling the field in 5 to 10 locations. Five to 10 leaves should be sampled at each location for a total of 60 leaves. Examine the underside of the leaves for the presence or absence of TSSM. Record the information on a field map so that "hot spots" can be identified and treated. The action threshold is when 25% (i.e., 15 leaves) or more of a 60 leaf sample is infested. When sampling a field, presence of predators as well as pest mites should be noted.

### *Root Weevils*

**ID/Life Cycle**: There are several root-feeding weevils that are damaging to strawberries; black vine weevil, strawberry root weevil, and the rough strawberry root weevil are the best known. Additionally, green leaf weevils have been found feeding on strawberries in MA and CT.

The black vine weevil overwinters in the soil as a partly grown larva, or "pre-pupa". Larvae resume feeding on roots in the early spring, causing the heaviest damage. Larvae pupate in late May and June for about 10 days. Adults begin emerging in June (600 GDD) and continue through July. Adults feed at night and hide around the base of the plant during the day. After two to three weeks of feeding, egg laying begins, usually in late July (approximately 1400 GDD). Larvae hatch in August (Approximately 1700 GDD) and begin feeding on roots. They continue to feed and grow until winter.

**Damage**: Larvae feed on roots and crowns, which can weaken the plants or lead to root rots. Adult weevils feed on leaves from May through August, causing notching of the leaf margins, which rarely leads to significant weakening of the plants. Under heavy infestation by root weevils, the plants decline, appear stunted and bear poorly. Infestations are generally in patches in the field.

***Monitoring and Management:*** Degree-day models can predict emergence and development. This can help guide scouting and management activities. Symptoms of adult feeding can be seen on leaf margins beginning in June. The nocturnal adults can be spotted at night with a flashlight. Traps can also be made by placing fold of burlap around the base of the plant, or by creating a pitfall trap by burying a paper cup at soil level. It is important to determine when the first adults are emerging so that control measures can be taken before they begin to lay eggs (2-3 weeks after emergence). Emergence is usually toward the end of harvest making chemical control difficult.

## Diseases

### *Gray Mold*

**ID/Disease Cycle**: Symptoms of gray mold include light brown areas on fruit; a powdery gray growth produced on rotted fruit and leaf tissue; and whole rotted berries that retain their general shape but become tough and dry.

The fungus overwinters in living plant tissue and proliferates in the spring as leaves die. Favored by cool, wet weather, the fungus infects new blossom tissue and remains latent until fruit starts to ripen. Then visible symptoms occur. Secondary infections may occur when spores that cling to ripening fruit germinate in moist packaging conditions after the fruit is harvested, causing uncontrollable storage rots.

**Damage:** The main damage to the crop is from reduced quantity and quality of yield. In years when wet weather prevails during bloom and ripening periods, significant crop losses can occur.

***Monitoring and Management:*** Consult scouting records from previous years to determine if carry-over inoculum is likely to be present. Scout fields weekly in the current year starting in the pre-bloom period for symptoms. Monitor weather conditions especially during bloom to determine if infection periods are imminent or have occurred.

***Black Root Rot Complex***

**ID/Disease Cycle**: Above-ground symptoms of this disease are a general lack of vigor, stunted growth, reduced yield and eventual collapse of plants especially during dry weather. Root symptoms consist of blackened feeder roots and, eventually, structural and perennial roots. Structural roots will rot from the outside to the center, leaving the core white for a period of time, unlike red stele where the core is usually red.

Black root rot has no simple causes or remedies. It is a disease complex, involving several pathogens combined with plant stress. The key pathogens include *Rhizoctonia, Pythium,* and lesion nematode. These pathogens are commonly found in soils but don't usually cause disease symptoms on healthy plants. But stressed plants are susceptible to infection. Strawberry plants may be stressed in a number of ways, such as drought, winter injury, root feeding insects or nematodes, poor nutrition, soil compaction, or improper herbicide use.

**Damage**: Plants may be weakened by poor root function or may collapse completely. The impact range from a reduction of yield in affected areas or may shorten the life of an entire planting from what would normally be expected.

***Monitoring and Management:*** Consult scouting records from previous years to determine if build-up of this disease is indicated. Scout fields after bloom to identify areas of weak vigor. Dig up plants in weak areas and examine the roots for possible cause.

***Red Stele***

**ID/Disease Cycle**: Symptoms of red stele infection are numerous: wilting; young leaves with a bluish-green tint; and older red, orange or yellow leaves. Severely diseased plants may die or remain stunted, producing few runners and small berries. When roots are cut open lengthwise, the core will show a reddish-brown discoloration. Plants showing symptoms usually occur in patches where the soil is wettest.

Red stele is caused by the soil-borne fungus that may be introduced by the movement of soil on tillage implements or runoff water from infested fields. This disease is very persistent and can survive in a field for many years, even if no strawberries are grown during that time. It persists in soil as thick-walled resting structures that are activated when the soil becomes wet. The fungus produces new spores within infected roots as they begin to rot and die, and these oospores are released into the soil when the roots decay, thus completing the disease cycle.

**Damage**: This fungus causes a root rot and wilt, and is a major disease of strawberries where cool, wet soil conditions occur. Depending on the extent of the infection and the plant's resistance, stunting or wilting and collapse of the plant will result.

***Monitoring and Management:*** Consult scouting records from previous years to determine if build-up of this disease is indicated. Scout fields after bloom to identify areas of weak vigor. Dig up plants in weak areas and examine the roots for possible cause.

# Strawberry Weed Management

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Weed management is among the greatest challenges of commercial strawberry production. Indeed, the most common reason for early bed failure, that is, why a planting lasts only one or two harvest seasons, rather than three or more, is weeds. Nearly all aspects of strawberry production can have an impact on weed populations, and growers must constantly focus on how their practices can prevent weeds from becoming established in the field.

From the beginning, any strawberry planting is threatened by weeds. The first step in managing this problem is to select a site where the weed pressure, especially from perennial weeds, is low. This means a site that has previously had well managed cover crops and/or cash crops that either smothered weeds or allowed effective cultivation. Avoid sites where tomatoes, potatoes, peppers, or eggplant have been grown in the past four years to prevent possible root rot caused by *Verticillium*. Do not plant strawberries into recently plowed sod, as this can lead to devastating weed problems in addition to white grubs, a common turf pest, which also feed on strawberry roots.

Delaying the planting date can help to manage weeds in a new strawberry bed. By preparing the ground in the fall or in the early spring, then allowing the first flush of spring weeds to germinate before planting, growers can kill those early spring weeds with a light cultivation, a contact herbicide or flaming, and plant soon after. By eliminating the first flush of weeds and planting into a warmer, drier soil, the need for early cultivation and hand weeding is greatly reduced. The delay in planting of four to six weeks can have a negative impact on the quality of your stored strawberry plants and you should discuss your plans with the nursery well in advance so that they will store and ship the plants appropriately. It also reduces the amount of time the new plants have to develop and form runners during the planting year, but early results from grower trials in New England have been very positive for this strategy.

Organic strawberry fields have typically been planted on open ground following the incorporation of a cover crop. Weeds are then managed with a variety of cultivation methods such as tine cultivators, blind cultivators (e.g. Lely) and/or finger weeders (e.g. Buddingh, Regi). This can be effective early in the season, as long as it is combined with vigilant hand weeding within the plant rows, where the cultivators can't reach. However cultivation becomes more challenging during the summer when the plants throw runners in the aisles in the path of cultivators. Using sweep blades to push the runners out of the way in front of the cultivating tines can work, but generally the need for hand weeding will become more intense as the season progresses. Flaming weed seedlings between the rows has also been used with some success in strawberries, but it is costly, and the burners must be well shielded to prevent burning the strawberry plants. This technique has the advantage of not disturbing the soil surface, which avoids bringing more weed seeds up from the soil.

Another strategy for managing weeds in the planting year is to use strip or zone tillage. In the late summer of the year prior to planting a cover crop of oats or winter rye is grown. Oats will winter kill, but rye will need to be crimped, mowed or killed with a contact herbicide (e.g. acetic acid) the following spring. The plant residue is left undisturbed on the soil surface except for narrow (8-12") strips or zones that are tilled for the strawberry plants. Leaving most of the soil surface untilled with a heavy plant residue will prevent most weed seeds from germinating. The rye residue last longer than oats, but killing the rye can be problematic. Zone tillage requires specialized equipment to make the soil strips suitable for good plant growth. The equipment is both expensive and heavy, requiring a fair amount of horsepower, but it can be used for many crops on the farm. Toward the end of the season, as the residue breaks down, weeds can once again become an issue, and hand weeding will be required within the tilled strips of the plant rows. After harvest the following spring the planting is usually plowed down and the field put back into rotation crops for a minimum of three years. A potential alternative to plowing down after harvest would be to seed the aisles to some sort of cover crop to prevent weed growth, such as oats, sorghum/sudan or buckwheat. The grasses should be mowed when they reach a height of two feet to prevent them from shading out the strawberries, and enough nitrogen fertilizer and water must applied to prevent competition between the cover crop and the strawberries. The cover crops will keep the weeds down in the aisles and the grass residues will help provide winter protection, but hand weeding within the plant rows will still be needed. Grower results with this technique have been mixed, but some studies have found it to be effective.

Plastic mulches can also be used to reduce weed problems in strawberries, although organic regulations restrict the length of time that plastic mulch can stay in place, generally to one growing season. Planting strawberries through black plastic will eliminate much of the weed pressure within the planting, but it prevents the use of runner plants to fill out the row. Therefore, plasticulture systems require about two to three times as many plants as a matted row system at planting, and plants are initially spaced only 8 to 12 inches apart. Once again, specialized equipment for making beds and laying plastic mulch is required, but vegetable growers would likely have such equipment already. Strawberries are typically planted later into a plasticulture system to reduce runner production. Runners need to be removed in this system, which is quite labor intensive. The plants are overwintered and harvested the next spring. After harvest the plastic must be removed, and the planting is generally plowed down. Research is underway to evaluate the feasibility of removing the plastic without disturbing the plants in the second season and allowing the planting to become a matted row for harvest a second year. It is hoped that weed problems would be reduced from having the soil covered for the previous year.
The experience of most organic strawberry growers using the matted row system is that the beds should only be fruited one year then plowed down and put into rotation crops. Trying to renovate a bed and carry it over a second year inevitably leads to major weed infestations and increased insect and disease pressure. However, using a plasticulture system in the first year and converting it to a matted row for a second year with minimal soil disturbance could provide a workable two crop system that would significantly increase the profitability of the planting.

Growers have also been trying to develop a renovation scheme for matted rows that would prevent the typical flush of weeds. This entails renovation without tillage. The thought being that much of the weed pressure following renovation is due to the tillage prescribed in the renovation process, i.e. bringing up new weed seed from the soil every time it's tilled. So, rather than tilling to narrow the rows after harvest, contact herbicides or flaming is used. The sprayer or flamer must be adequately shielded to prevent burning the plants in the center of the rows (they should be narrowed to about 8 to 12 inches). Repeated burning will be necessary to manage weeds between the rows through the summer, and regular hand weeding within the rows will also be necessary, but by not tilling the soil, growers are finding that weed pressure in the second year is significantly reduced. Yields tend to be lower and fruit size smaller in the second harvest year, but it seem to be profitable enough to make it worthwhile.

The one harvest year rotation is probably still the best option for most organic growers (plant year one, harvest year two, plow down and plant to rotation crops) to manage weed problems in strawberry beds. However, some of the new strategies being developed may allow growers to extend the productive life of strawberry beds and thus improve their profitability. With any new strategy, it is critical that strawberry growers maintain soil health and fertility and prevent the build up of pest organisms; therefore each new technique must be evaluated not only in terms of how it affects short-term yield, but also how it may impact the long term success of future crops.

**Annual-bed System Strawberries at Kilpatrick Family Farm**

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Kilpatrick Family Farm is a mixed vegetable, fruit and poultry farm located in Middle Granville, NY zoned 4b. The majority of our sales are through a 200 member CSA as well as several farmers markets in Saratoga Springs and Glens Falls, NY. We also sell a limited amount if items wholesale through Co-ops, restaurants, and to other CSA's. The farm is approximately 500 acres of owned, rented and leased land. It consists of 40 tillable acres, 100 pasture acres, and the balance, woodlot and scrub. We plant between 12-14 acres of vegetables and fruit every year.

Because of our mixed retail opportunities it is imperative for us to have a wide diversity of crops year-round. Strawberries provide this diversity through our June sales of fresh strawberries and then winter sales of frozen strawberries.

We chose using the annual bed system over matted rows for several reasons:

1. Reduced disease pressure because of the open nature of the plant and relative short lifespan of the crop.
2. Chandler, the variety that we use for this system, has flavorful large berries and an open plant habit, which allows easy identification and harvesting of ripe fruit.
3. Quick turnover of the crop. The fall planting and next spring harvest allows the crop to be in and out of the field relatively quickly, allowing additional cash crops, or cover crops, on that land in the same year.
4. Relatively low labor is required for this system There is none of the runner and flower pruning that is normally associated with matted row system.
5. Because of the short time frame of this crop, perennial weeds are easily controlled mechanically.

The basics of this system are as follows:

First week of August- tips are purchased and propagated in the greenhouse. They are started in 50 cell trays and misted for 30 seconds every 15 minutes for the first week, reducing the frequency every week as they establish in the cells. We also treat them with micronutrients and root shield for increased vigor.

First to second week of September- Ground is prepped, compost and soil amendments are spread, and then raised plastic beds are made. The plants are then set in 3 staggered rows, 12"x12" apart. Beds are mulched between using our Teagle bale chopper.

Middle to end of November- plants are row-covered for the winter. Strawberry plants are highly desirable to deer so we use Typar 518 row-cover, which the deer can't paw through. At this time we also place bait stations filled with Agrid3 for vole control under the cover.

End of March- as soon as the snow melts we remove row-cover, check plant health and add 5-10 lbs of nitrogen per acre. Row-cover is then reapplied. We will also do leaf analysis and then add any needed amendments based on recommendations.

End of April- We start checking for blossoms; as soon as 10% of the plants are blossoming we will remove row-cover for good, applying again only for nights that could potentially frost. We also start a consistent irrigation schedule at this time, aiming for at least 1" of water per week.

End of May- We typically begin harvesting berries the last week of May. At this time we will apply bird netting over the entire field to keep cedar waxwings and robins out of the field. The netting is only removed during harvest.

End of June- The last week of berry picking we invite our CSA members for a U-Pick event on the farm, cleaning out the field. As soon as this is done, the netting is rolled up, any irrigation pipe is removed and the section is tilled under. Several weeks later, after crop residue is broken down, we plant the next crop.

Our berries are marketed through our Farmer's markets, CSA and wholesale accounts. We also freeze any extra we may have for winter sales. Our prices are usually $5 a pint, 2 for $9, or $40 for a flat of 12. Wholesale prices usually work out to be around $30-36 a flat.

We have been very happy with our success with the annual bed system. It supplies us a consistent supply of beautiful, flavorful berries starting at least a week before conventionally grown matted row berries start producing. Our yields are usually averaging 12-16,000 lbs per acre or between $50-70 K per acre gross.

**Tips From the Sweetpotato Experts: Sweetpotato Production in North Carolina**

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The North Carolina sweetpotato industry is comprised of approximately 400 family farms plus a number of packers and affiliated businesses that produced nearly one billion pounds of raw sweetpotatoes during 2011. The number of growers producing sweetpotatoes in North Carolina has increased due to growing consumer demand for sweetpotatoes. The farm gate value of sweetpotatoes was about $226 million in 2011, and has increased over $100 million since 2002. Increased consumption of sweetpotatoes has resulted in the increased value and sales of sweetpotatoes in the United States. Per capita consumption increased substantially from 3.7 lbs in 2002 to 6.3 lbs in 2010. One of the key drivers for the increased consumption of sweetpotatoes are its health benefits. Another important factor is the increasing sales of value added sweetpotato products, especially frozen (i.e, fries). North Carolina is the number one sweetpotato producing state in the United States and accounts for approximately 45% of the crop production and acreage. It is in the best interest for North Carolina sweetpotato growers to optimize their growing practices that results in a high yielding, quality crop that is profitable. North Carolina State University has a large research and extension team of faculty in multiple disciplines; sweetpotato breeding and genetics, microprogation/plant propagation program, cultural management, insect management, disease management, weed management, biological and agricultural engineering (storage and curing structures, machinery), postharvest, and economic or budget analysis. The main component of my program involves production, although I will touch on many of the areas mentioned as our sweetpotato team has very integrated programs.

There are several considerations when producing a crop of sweetpotatoes. I will comment and discuss the following topics; use of high quality "seed", plant production, variety selection, planting, fertilizer management, soil moisture, pest management, and harvest and storage considerations. I will spend a little more of my time describing greenhouse plant production since it was indicated to me that this was of particular interest to growers in the northeastern part of the United States. All the subject areas mentioned previously are important and I will try to make some key points for each.

Starting with high quality seed for any crop is critical and sweetpotatoes are no exception. Sweetpotatoes are vegetatively propagated, thus there can be a carry over of pest problems from one season to the next. In particular, sweetpotatoes will harbor viruses which can affect both yield and quality. To help overcome this problem, there are about 10 certified "seed" growers in North Carolina who provide the growers in North Carolina, out of state growers and even international growers with certified plants or "seed" that are of the highest quality. Certified sweetpotato seed growers will maintain high quality seed by annually purchasing virus-tested plants from the Micropropagation Unit and Repository at North Carolina State University. The plants that the certified sweetpotato seed producers purchase from North Carolina State University are elite plants that are maintained in a vegetative state in tissue culture and screened cages (this minimizes the chance for any mutation and the deterioration or “running out” of the variety over time). Growers need to avoid growing sweetpotatoes from the same stock for more than 3 growing seasons in order to maintain high yield and quality in their production. Beauregard variety is extremely sensitive to the feathery mottle virus and shapes can become distorted and appearance unsightly due to bands forming on the roots if conditions are favorable in a given year. This symptom and disease is known as russet crack.

Variety selection is very important, and location where the sweetpotato is to be produced is critical. Sweetpotato is a tropical plant; however, it is often produced in temperate climates. The sweetpotato thrives when grown in high temperature conditions. The optimal temperature for growing sweetpotatoes is between 85 to 90 F. Because at least 90 favorable growing days are needed to produce a reasonable crop, although 105 days is more typical, the window for planting a crop in cooler, northern climates is narrow. There is more flexibility when planting sweetpotatoes in the southern United States due to a longer, warmer growing season than in the northern United States. The Beauregard variety tends to size as quickly as any sweetpotato variety currently available. However, ‘Covington’ sweetpotato is grown on 80 to 85% of the acreage in North Carolina. ‘Covington’ sweetpotato generally do not yield more than ‘Beauregard’ sweetpotato. The reason North Carolina sweetpotato growers choose to produce ‘Covington’ is because it packs out much higher than ‘Beauregard’ sweetpotatoes.

Plant production in North Carolina is typically done with plant beds that are planted in mid March to early April. The seed beds are covered with plastic and a drip line or two are placed in the bed for watering and fertilization purposes. As plants emerge from the soil and day-time temperatures increase, the plastic cover over the plants is pulled back or removed. It can turn too hot under the beds (over 125 F) if the plastic is not removed as temperatures increase later in the spring. This can cause the seed to rot in the bed. The majority of the plants for North Carolina sweetpotato growers are obtained from these outdoor beds beginning in mid May until planting is completed in late June or early July.

Some plant production is done in greenhouses rather than in outdoor beds in North Carolina. By growing in protected greenhouse conditions in which temperatures can be regulated, sweetpotatoes can be planted earlier in the season than if produced in outdoor beds. In North Carolina, approximately 2 to 4 weeks are usually gained by growing greenhouse sweetpotato plants. This usually results in earlier harvest, and can result in higher yields, especially if grown in climates that are cooler than North Carolina. Plants can also be managed so they are uniform in size. Typically, about 16,000 plants are planted per acre.

For production in the greenhouse, a plastic layer is placed on the ground and holes are punched to allow for drainage. Soil mix is usually composed of 20% sand, 20% peat, 20% lime and perlite, and 40% aged bark, which is screened to be no more than ¾ inch in size. One cubic yard will cover approximately 80 $ft^2$ 4 inches deep. ”Seed” potatoes should be placed on the soil mix next to each other so they are almost touching. Approximately 25 bushels of seed potatoes are needed to produce one acre of sweetpotatoes as one bushel will yield between 600 to 1000 plants per bushel. The sweetpotato seed should be covered with no more than 1 inch of soil.

Appropriate fertilizer needs to be added and irrigation applied daily or every other day, depending soil type, weather conditions, and stage of plant growth. Plants will need to be mowed several times to obtain more uniform sized plants and this must be done a couple of times. Chemical control recommendations must be followed according the label. Once plant harvest(s) is/are complete, the roots and soil should be removed from the greenhouse. The greenhouse should be closed off and disinfested using solar radiation.

It is important to use high quality plants that are of good size (8 to 12 inches from cut point to growing point. Smaller plants may have reduced yields or they may not survive if planted under stressful growing conditions. Additionally, at least two nodes of the plant should be covered by soil to promote survival and yields.

Fertilizer program can vary due to variety. For example, Beauregard variety is an excellent nitrogen scavenger. About 50 pounds of nitrogen per acre for the season should be plenty. It is also advantageous to apply the nitrogen one time at lay by as this has been shown to increase yields in some cases. For 'Covington', a split application of nitrogen is recommended, one about 7 to 10 days after planting, the second application at layby. Total nitrogen for a crop of 'Covington' sweetpotatoes is 90 to 120 pounds per acre for the season. About 50 to 80 pounds per acre phosphate and 150 to 200 pounds potash is usually appied for producing a crop of sweetpotatoes.

Soil moisture at planting at levels that are not too wet or too dry is very important to achieve a good set of storage roots. The number of storage roots a plant produces is often determined within the first two to three weeks after planting.

The main weed pests in North Carolina are Palmer amaranth and nutsedge. If these and other weeds are not controlled, yields can be substantially reduced. Valor, Command and S-metalochlor are commonly used weed control compounds utilized by North Carolina growers for weed control. The most destructive insects in commercial North Carolina sweetpotato fields are wireworms and flea beetles. Grubs are more problematic and can be extremely damaging to sweetpotato crop if present in the field. Lorsban and bifenthrin are the most common chemistries used to control these soil borne insects.

Sweetpotatoes are primarily hand harvested in North Carolina. Because the sweetpotato is sensitive to skinning, the root needs to be handled with care to minimize damage. In order to heal damage on the root caused at harvest, sweetpotatoes are placed in curing rooms for about 5 to 7 days at 85 F and 90% relative humidity. After curing, sweetpotatoes are stored until ready for sale in rooms maintained at 60 F and 90% relative humidity.

**Varieties, cultural practices, and post-harvest management of sweet potatoes for New England**

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Although sweet potato (*Ipomoea batatas*) is a tropical crop that benefits from high temperatures and a long growing season, some varieties can be grown successfully in Northern climates. With their diverse colors, excellent flavor and long storage life, sweet potatoes may make a nice addition as a specialty crop for Northern growers. From 2006-2013, we evaluated over 18 varieties of sweet potatoes at the University of New Hampshire in Durham, NH (USDA hardiness zone 5B). Our primary objective was to determine which varieties produced high yields of good-tasting and marketable roots in Northern New England.

Sweet potatoes were started as 'slips', or rooted cuttings, which were obtained from several suppliers (See Table 1). Slips were shipped in bundles near our target plant date of June 10, when soil temperature is consistently above 60F. If slips could not be transplanted within 2 days, bundles were temporarily set into pots with potting mix and were kept moist until the field was ready. Transplant dates ranged from June 6 to June 22.

Slips were planted on raised beds covered with black biodegradable plastic mulch (BioTelo, Dubois Agrinovations, Quebec CA). Following soil test recommendations, 25 lbs N and 200 lbs $K_2O$ per acre were incorporated prior to laying plastic. Slips were transplanted 9 inches apart in single rows on 3' wide raised beds spaced 6' on centers.

Sweet potatoes were harvested as late as possible in the fall while the soil remained above 60F. Harvest dates ranged from September 27 to October 15. After hand digging, sweet potatoes were graded, sorted and removed from the field. Roots were cured for 5-8 days in an empty unheated greenhouse, which fluctuated between 85F day and 60F night. After curing, roots were transferred to long-term storage, 55-60F and 75-80%RH. Brix, dry matter, and taste tests were done in mid-November, 30-39 days after harvest.

All experiments were planted in replicated designs with at least three replicates of 8 slips per plot. Varieties that did not perform well in the first two years were dropped, and plot sizes and number of replicates were expanded in subsequent years for those varieties that showed good quality and high yield potential. Data from experiments completed over several years are reported in summary form. The specific methods used are described below.

Yield: Roots were classified as: marketable – few blemishes, tapered at either end, and >1" in diameter; #2 – undersized (<1" diameter); and #3 – unmarketable due to severe blemishes that would compromise storage.
Brix: This measures percent soluble solids in the flesh, most of which are sugars. Small cubes (1-2cm$^2$) of flesh were frozen and thawed. Juice was then squeezed onto a hand-held refractometer.

Flavor: Sweet potatoes were baked, cooled, and sliced into discs. Participants sampled and rated each variety for flavor and appearance, using the following ratings: 1-poor, 2-below average, 3-average, 4-very good, and 5-outstanding. Each year, each variety was rated by at least 22 people.

**Results:** Yields varied between years. In general, the highest yielding varieties produced approximately 2.5 lbs or more per slip, which corresponded to 24,000 lbs per acre at the spacing used in our experiments.

Sweet potato flavor ratings were consistent between years. Visual appearance affected overall ratings; many tasters commented unfavorably on white-fleshed roots, which did not fit their image of a typical sweet potato. While all varieties had average or better flavor, there were significant differences between varieties. Average brix (% soluble solids) ranged from 8.5-11.5%. After harvest, brix values increased steadily for the 21 days after harvesting, and then began to level off. High brix measurements were correlated with good flavor ratings. Therefore, eating quality improves dramatically during storage of roots after digging.

Based on both yield and flavor ratings, the varieties most suitable for commercial production were the orange-fleshed cultivars Beauregard and Covington. O'Henry, White Yam, Japanese, and Carolina Ruby performed well, but would require markets interested in novel colors and textures. Georgia Jet, Vardaman, and Centennial each had significant limitations but may be worth consideration, depending on marketing options and the desire for novel products.

**Table 1. Varieties evaluated in replicated trials over multiple years (>2) in Durham, NH.**

| Variety | Slip Source[1] | Skin Color | Flesh Color | Yield Potential | Flavor | Comments |
|---|---|---|---|---|---|---|
| Beauregard | St, Sc, GPF | Rose-Copper | Orange | High | Good | Prior to the release of Covington, this moist orange-fleshed variety was the standard for commercial production. Attractive, high marketable yields. |
| Covington | Sc | Rose-Copper | Orange | High | Excellent | More uniform, higher marketable yields, and sweeter than Beauregard. |
| O'Henry | Sc, St | White | Yellow | High | Good | Flesh is creamy yellow and moist when baked. White sport of Beauregard, skin greens with sun exposure. |
| White Yam | St | Tan | White | High | Good | Starchy and drier, slightly less sweet than other varieties. Smaller roots, attractive and uniform |
| Japanese | Sc | Rose-Purple | White | High | Good | Smooth and starchy white flesh has a unique smooth texture. Attractive purple skin. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Carolina Ruby | Sc, GPF | Dark Red | Deep Orange | Medium | Good | Unusual deep red, rough, skins. Produced variable and odd shaped roots. |
| Georgia Jet | St, GPF | Red-Copper | Orange | Medium | Excellent | Severe cracking tendency, especially in moist conditions. For home gardeners only. |
| Vardaman | St, GPF | Gold-Brown | Deep Orange | Low | Excellent | Slender roots did not size up, limited yield potential. Very high carotenoid content, excellent flavor. |
| Centennial | St | Copper | Orange | Low | Good | Slender roots did not fatten in NH growing season. |

[1] Slip sources are as follows: St - Steele Plant Company, Gleason TN; Sc - Scott Farms, Lucama NC; GPF -George's Plant Farm, Martin TN.

We also evaluated the following varieties in small replicated trials. None of these advanced to larger replicated trials because they either had very low yield potential, or slips were available in extremely limited quantities, or both. We felt that both of these factors precluded commercial production in our region.

**Table 2. Varieties not recommended for commercial production based on limited trials in NH.**

| **Variety** | **Skin Color** | **Flesh Color** | **Comments** |
|---|---|---|---|
| Gold Star | Pink | Light Orange | Showed good potential, limited slip availability |
| Regal | Red | Deep Orange | Showed good potential, limited slip availability |
| Frazier White | White | White | Showed good potential, limited slip availability |
| Tainung 65 | Purple | White/light pink | Produced very few roots, all of which were oversized and irregularly shaped. |
| Darby | Red | Deep Orange | Very poor yields, limited slip availability |
| Nancy Hall | Tan | Yellow | Very poor yields, limited slip availability |
| Porto Rico | Tan-Orange | Orange | Very poor yields |
| Korean Purple | Purple | Purple | Very poor yields, limited slip availability |
| Orange Oakleaf | Pale orange | Orange | Severe scurf, poor yields, limited slip availability |
| Jewell | Pale orange | Yellow-Orange | Low yields, limited slip availability |

**Conclusions:**

- Several sweetpotato varieties can be grown in Northern New England.
- Brix levels (and corresponding eating quality) increase dramatically after harvest. Regardless of variety, to get best flavor, it is important to wait at least three (3) weeks after harvest before eating.

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**Grape Cultivar Selection in New England**

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As with site selection, vineyard owners pretty much have one shot at getting it right, so this is another important decision to make before a vineyard is even planted, and it requires a similar amount of due diligence. Selecting cultivars (or varieties) to be planted can be a complicated matter since it often involves competing forces and emotions, such as, "should I plant the grapes that I like to drink" or the natural tension between the varieties with the best viticultural potential for the site, or the greatest marketability for the area (often different varieties fulfill each of these needs). In any case, it is best to evaluate the potential for both, and then decide what to plant. Visit local wineries and vineyards and find out what they grow, make and sell successfully, this data will be very helpful. But there are always pioneers or outlaws that break local convention and try oddball varieties, consider Petit Manseng in Virginia, or Gruner Veltliner in Pennsylvania, both have become very successful and have experienced wider adoption.

In New England, the limitations on cultivar selection are mostly enforced by the climate, which is cold in the winter, and potentially humid and wet in the summer. Since a dead vine does no one any favors, cold hardiness ranks high among desirable characteristics. The adoption of cold hardy hybrid varieties from the University of Minnesota's grape breeding program, along with varieties created by a private grape breeder in Wisconsin named Elmer Swenson, along with new and traditional inter-specific hybrid varieties developed in the past and more recently by the grape breeding program at Cornell University, have transformed the wine industry in New England and opened the door to economically sustainable wine growing in the region. Though they have been around for almost two decades, they are still experimental in nature, as growers, wine makers, and researchers continue to experiment with the best way nurture fine wine from them.

Vinifera snobbism is rife in the wine consumer world, and even in the wine industry, but in rural areas where the palate is more broad and accommodating, it appears that non-familiar names of wines like Marquette and La Crescent are accepted. No one will mistake these wines for a Pinot Noir from Burgundy or a Riesling from the Mosel, but if well made they deliver a fine wine experience to a large segment of wine consumers. And as the wine industry in New England grows, these names will become more familiar and accepted.

During the site evaluation process it is possible to get a 30-year site climate history that will reveal the cold temperature and length of growing season history of the site using interpolated climate data. These critical indices will guide the choice of cultivars. If winter temperatures regularly dip below $0^oF$ and the growing season is in the 150-day range, then the new hybrids are well worth considering. Knowing the approximate heat summation, measured in growing degree days (base $50^oF$) can be very helpful to guide your cultivar selection.

Consumer considerations include preferences such as dry or sweet (or anywhere in-between), red or white, native varieties with their distinctive "foxy" aromas and flavors, acid and alcohol levels, and, of course, prices. Consider the saying that wine consumers, "talk dry but drink (and buy) sweet." In rural areas, sweet wine sales will dominate.

Wine making can be a challenge because variable weather conditions within and between vintages can result in uneven grape and wine quality. Most hybrids are known for their high acid, which makes it difficult to produce a balanced wine. Blending, and other cellar treatments, can temper wine acidity, but it's best to achieve it in the vineyard. A knowledgeable and well-trained wine maker is definitely an asset in a cool to cold climate region.

Hybrid cultivars usually offer greater disease resistance and need to be sprayed less than their *vinifera* cousins. This and other features, makes their cultivation easier and less expensive. They thrive on high wire trellis systems which are less expensive to install and maintain, once the vines are mature. The yields are generally higher than *vinifera* varieties but the prices they command are lower. Most hybrids do not need to be grafted onto phylloxera-resistant rootstocks which make the vines much cheaper to buy. However, hybrids like Traminette and Chardonel, that have some *vinifera* parentage, should be grafted just to be safe.

Can *vinifera* succeed in New England? It's all about temperature and season. Along the coast of Connecticut and Massachusetts wineries like Newport Vineyards, Sakonnet Vineyards, and Westport Rivers Winery produce excellent wines from European varieties but all of these wine growers will tell you what a challenge it is each year. Further north, the focus must be on more cold hardy cultivars such as Chardonnay, Riesling, Rkatsetelli, and Cabernet Franc. If any of these varieties is selected, the best clones must also be considered. *Vinifera* vines must be grafted onto rootstocks, and the choice of rootstock is extremely important and should not be taken for granted. A low vigor stock like *Riparia Gloire* can help to push fruit ripening, allowing for an earlier harvest and more time for a vine to store insulating carbohydrates before the leaves fall and winter arrives. Rootstocks indirectly impart other potentially valuable characteristics to a vine including tolerance to nematodes, drought, soil alkalinity and acidity, wet soils, and possibly crown gall.

In addition to length of growing season needs, the time of bud break and harvest is important relative to spring and fall frost events. It is very difficult to manage around frost hazards, especially on an inadequate site. If vines and/or fruit are frosted, then both yield and quality are in jeopardy, so mid to late bud break varieties with short growing season requirements are highly desirable.

There are many lists of suitable grape cultivars that can be found in the reference resources at the end of this article. But it is best to make choices based on information gathered in the field, by looking at vineyards, talking to growers and wine makers and tasting their wines. Of course, try to pick the best practitioners for reliable information and examples. It is prudent to mix cultivars based on the risk assessment of the site, i.e. a colder site has a greater proportion of native and cold hardy hybrids while warmer sites will contain some *vinifera*.

Since Eastern wine growers do not have the ability to field graft like vineyards in warm, arid regions, there is a greater demand that the initial cultivar selection be the correct one to go the distance (20-30 years of a productive vine's life). This places great demands on the vineyard owner to make the right choice. A lot depends on the kind of wine being made, e.g. a sweet, native wine like Concord or Niagara will have different requirements than a dry Chardonnay or Cabernet Franc. The conditions and methods that allow each type of wine to succeed must be carefully created in the vineyard, and then extended into the cellar. New England is still very much in its pioneer phase of development, so there is a lot of experimenting and guessing going on. Until its unique terroir is really understood and mapped, wine growers will rely on a healthy measure of intuition, knowledge and luck to succeed.

Cultivar, clone and rootstock selection resources:

- Wolf, T., et al. *The Wine Grape Production Guide for Eastern North America.*
- Chien, Mark. *A Practical Guide to Developing a Commercial Wine Vineyard*. Available as a PDF document on the Pennsylvania Wine Grape Network Website (new grape grower section).
- Plocher, Tom, and Parke, Bob. *Northern Winework: Growing Grapes and Making Wine in a Cold Climate.*
- Smiley, Lisa. *Cold Climate Cultivars: A Review of Cold Climate Grape Cultivars*. http://viticulture.hort.iastate.edu/cultivars/cultivars.html

# Recent advances in vineyard sprayer technology

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*In order to minimize pesticide in fruit crops, researchers at Cornell University are developing a number of automated precision canopy sprayers. This presentation describes new developments in canopy spraying to improve deposition and reduce drift.*

Precision spraying requires a well-tuned sprayer; attention to detail is necessary to ensure the spray hits the target and doesn't drift.

In previous research and extension presentations on sprayer development, I have shown growers how to reduce the airflow being emitted from an airblast sprayer (the volume and speed of air is too great for modern canopies). Many airblast sprayers used in vineyards were designed for traditional apple plantings, not grapevine trellises. For example, some former orchard sprayers create around 50,000 cubic yards of air per hour and a well-pruned canopy might only require 3,000 cubic yards of air – this is extreme over-capacity.

Initially I showed growers deflectors to direct the air towards the canopy. This was followed by the ubiquitous "Cornell doughnuts" to restrict air coming into the fan. An alternative was to reduce tractor PTO speed for growers operating on flat land, a 25% reduction in PTO speed resulted in a 75% reduction in drift. An alternative for growers on slopes was to use a hydraulic motor and flow regulator to adjust fan speed.

Over the last three years we have developed and patented adjustable louvres to retrofit onto the air outlet of the fan. The louvres are moved across the airstream using an electric actuator - each side is independent of the other, allowing adjustment according to the direction of the ambient wind for example. Why would we wish to adjust the air? To keep the spray plume within the canopy, thus improving deposition and reducing drift considerably. Canopy density changes as the season progresses, with different varieties and trellis designs, we know we should change liquid flow according to canopy characteristics, should we not consider changing airflow?

In a series of Extension twilight meetings, using fluorescent tracer and blacklights, growers are able to see how only a small amount of spray is actually deposited on the target, yet the rachis and trellis wire is well covered in small droplets. Aerodynamics plays an important part in improving deposition, slowing down air speed improves deposition.

The presentation will conclude with our most recent advances in the use of canopy sensors to detect canopy volume and adjust the airflow and liquid flow in real-time.

**Vineyard Site Selection and Design in New England**

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Wine growing regions with challenging climate conditions require more rigorous vineyard site selection. Because of cold winters and often wet summers and harvest seasons, New England vineyards benefit greatly from careful site selection. Mainly, grape growers should be looking for soils and topography that shed water and air, and depending on the type and style of the wine, grow a small to medium size vine.

New cold hardy hybrid varieties have opened wine growing to cold regions in the U.S., and these varieties are already being successfully grown in New England. A recent cold hardy hybrid workshop with John Thull, the research vineyard manager at the University of Minnesota where many of these cultivars were developed, revealed that many of the same viticultural requirements for successful cultivation of European varieties apply to the cold hardy hybrids as well, e.g. canopy and crop management, trellis and training systems, integrated pest management, etc. That generally infers that site requirements for cold hardy and *vinifera* grapes are also similar.

It might be surprising to ask a grower to determine what kind of wine his grapes are destined to make before the first vine has been planted, but the type, style, and often the price-point of the intended wine will largely determine the characteristics sought for in a site to grow that particular wine. In the Finger Lakes, a production wine like Hazlitt's Red Cat requires very different grapes than a Pinot Noir from Heart and Hands Wine Company. For sure any wines being made from *vinifera* or high quality hybrid grapes will require equally high quality vineyard sites to consistently produce grapes that meet the quality parameters.

Paramount viticultural goals are to grow vines with a short vegetative cycle that will, a) ripen its fruit as quickly as possible, and b) have superior cold acclimation habits. Fortunately, the same site features, vineyard design, and viticulture practices serve both of these goals, but site selection is the most important!

Generally, in a cold area warm sites are desirable, and the converse for warm wine regions. In ancient times, the Romans would always look for areas on a hill that snow would first melt as the best place for grapes. Climate is critical to wine production and, in general, a warm site with warm soils is highly desirable, and certain features will enhance these qualities. A site's climate should be evaluated at the macro- and meso-climate scales for their viticultural potential. If possible, rain shadows should be sought, and low winter temperature records (30 years using interpolated climate data) analyzed for the potential for winter injury to vines. Other key climate attributes include length of growing and rainfall (annual and distribution) amounts.

Drainage and fertility are key features of any viticultural soil. If the intent is to grow a large and productive vine, high water holding capacity and ample fertility are preferred. If a smaller vine is desired, then less soil moisture and nutrients are necessary to limit the vegetative capacity of the vine. This is referred to as soil capacity. Capacity can be ameliorated only slightly and with great difficulty, so these qualities should already be present in the vineyard site.

New England has, for the most part, fertile soils, which are often at odds with the goal of growing a small to medium size vine. Wine growers should seek soils with well to excessively-well drainage classifications, with up to 50 percent rock content – but the amount and quality of "rock content" should be closely examined. Also, limited organic matter (<2%), and especially available nitrogen, are distinct advantages. In general, it is much easier to "bulk up" a vine than to devigorate it, so lower capacity (lighter and warmer) soils are preferred.

Absolute and relative elevation and topographical features are also very important. High sites are cooler during the growing season which can hamper fruit ripening but they often shed cold air during frost and freeze events better than lower sites. Vineyards should be placed on convex surfaces that tend to shed water and air. Any place that air or water can pool (concave surfaces) will be detrimental to vine health and grape quality – grapevines do not like wet feet, they will harden off slower and be more susceptible to winter injury, and cold air can accumulate and cause frost and freeze damage. Slopes, up to whatever amount is considered safe and efficient to work (usually up to 30%), can greatly enhance soil and air drainage. Flat fields on the top of a hill can make fine vineyard site and east to southwest orientation is preferred.

In general, trees make poor neighbors to vineyards. Of course, New England has lots of trees, so this is a difficult relationship. Trees harbor insect pests and diseases, as well as birds during harvest, and some trees like black walnuts, actually exude a toxin from their roots that prevent vines from growing. Trees also block the breeze that can help vines to dry out after summer rains, so if it's possible: avoid trees.

When site capacity and potential vine size, and meso-climate conditions are determined, the vineyard can be properly designed. Spacing between rows and vines will be influenced by the potential vine size, and this will determine density. More productive sites will have rows and vines spaced wider, typical 9-10' between rows and 5-6' between vines. Lower capacity sites may be 6-7' between rows and 3-4' between vines.

Vine size also influences trellis system choice. A big vine is best grown on a divided trellis like Scott Henry or lyre, which consists of over-under or side by side foliage and fruit panels. This essentially doubles the number of linear feet of trellis in a unit area and allows big vines to spread out more comfortably. On moderate capacity sites single canopy systems are used, like Vertical Shoot Position or high wire cane or cordon. Trellis fruiting wire is usually between 30 to 36 inches, and VSP canopy height is 6 feet, high wire systems are trained at 5-6 feet.

Row orientation is ideally north to south, or perhaps 10 to 20 degrees northeast to southwest to take full advantage of the morning sun and deflect some of the warmer later afternoon sun. On hillside rows should be planted up and down the hill.

Varieties should be carefully considered (see accompanying article). The cold hardy hybrids are a good choice for New England, as are some native and traditional hybrid grapes. They are more cold tolerant and generally more disease resistant than *vinifera*, Frost, especially in the spring, can hinder crop production so varieties with a late bud break or early maturity may be prudent choices. All *vinifera* and some hybrids may benefit from rootstocks, mainly for protection from the root louse phylloxera but also to manage vine size, or impart some other indirect benefit to the vine.

If a soil is too wet it would be wise to consider installing drain tile to help remove excess water. Conversely, if it is too dry, drip irrigation may be necessary, and an adequate water source must be available.

Almost certainly a vineyard in New England will require a fence to prevent deer from browsing newly planted vines or grapes before harvest. Consider excluding rabbits, raccoons, and other leaf and grape eating pests.

Visit vineyards and wineries that have similar goals for grape and wine production to see what they are doing, and talk to the vineyard manager and/or wine maker about site selection and vineyard design features that might apply to your site.

Site selection and vineyard design resources:

- Wolf, T., et al. *The Wine Grape Production Guide for Eastern North America.*
- Chien, Mark. *A Practical Guide to Developing a Commercial Wine Vineyard*. Available as a PDF document on the Pennsylvania Wine Grape Network Website (new grape grower section).
- Lakso, Alan, et al. *New York State Vineyard Site Evaluation*. http://arcserver2.iagt.org/vll/learnmore.aspx
- Smart, Richard and Robinson, Michael. *Sunlight into Wine: A Handbook for Wine Grape Canopy Management.*

**Broccoli Production in Rhode Island**

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An old farmer once told me the way to make money in farming was to critically assess the soils, water and climatic conditions of where you are going to farm and then take advantage of them. He said, "figure out what the climate is telling you to grow and let it help you". We farm on a peninsula sticking out into Narragansett Bay, and our house is less than a mile from the ocean. It took me a while to understand it, but I now get the huge advantage the heat sink of Narragansett Bay plays on the success or failure of our growing practices. Needless to say, with the effect of global warming firmly in place, we have added 30 harvestable days to what we had back in 1980 when we started farming. Last December 27, 2012, we harvested 32 bushels of beautiful first cut broccoli without the use of any reemay covers!

Conversely, on the other side of the season, our land is very late in warming up. We go from mild late winter weather to a sudden burst of warmth that is a shock to us and as well to our plants. Thus, after many years of trying, we no longer grow spring broccoli or cauliflower. Too often it bolts or has any number of other problems just before we want to cut it. Our first harvest goal for any broccoli is August 30th. Depending on my longer-term estimate about the heat index of the summer, we will attempt some mid-summer cauliflower production. But more often than I want to remember, we will try growing broccoli only to have it get some heat damage during a very hot summer afternoon. Ruth Hazzard has written extensively about this; it only takes five hours of above 97 degrees to mess up an adolescent broccoli rosette. There is a critical couple of days when the broccoli plant is shifting from a vegetative to a reproductive state. If the newly formed rosette gets heat damage you will get deformed heads when it comes to harvest time. The day the damage is done you can't even see it but it is there and it can have a critical impact on your final harvest quality and profit. In California's' northern high mountain broccoli production areas, they are so tuned into to the heat damage possibilities, they will harrow in an entire crop if they are sure the daily heat index maximum is reached. This is why we grow four acres of broccoli, cauliflower and various kales but just for our fall markets.

Our first step is field preparation. We often will have to make a decision on how to manage the winter cover crop in May. If it is a healthy annual rye, we will plow it down at 24 inches and put an oat/field pea cover crop on afterwards. Depending on when we plant a particular field, we may have to turn in the pea/oat cover in a bit early to avoid oats from setting seed and becoming weeds. If this is the case, we will try and sneak in a bare fallow period to lessen the surface weed bank before the main crop. Our Lely tine cultivator is used in combination with a Canadian "S" tine wheat weeder. The latter is very effective for stirring the soil a bit more aggressively than the Lely especially after a heavy rain. But our operative goal is to not disturb the soil any deeper then 1-2”. Goal #1: Get soil ready while reducing the surface weed bank.

Our next focus is seedling management. We use “98 deep” plug trays from Landmark. Our soil is Vermont Compost Co “Forte Lite”, which we cut 30% with straight peat moss. We do this because we like our plugs healthy but not too green. If too succulent, they seem more susceptible to flea beetle predation.

Other plug protocols:

a) When second true leaf is fully open; fertilizer is reduced and they are moved outside for wind, rain and cool nights to harden them off and stiffen them up.

b) At four true leaves (20 days) watch root mass to be sure it is not getting too tight; if so transplant within five days.

c) Day of transplanting, spray with Dipel / Kaolin Clay/ Pyganic/ mix to ward off first flea beetles and other predators. Dip whole trays into seaweed and chelated phosphorus starter charge mix before leaving farm.

Field Prep: dealing with flea beetles has become a high priority, in fact so much so, it dominates even our fertility management. We are also in no hurry to feed weeds either. So we shoot for only 60 lbs of N. at the day of transplanting. Our main organic fertilizer source is Krehers 4,3,3. which is what we use to achieve all our broccoli fertility goals. Being organic means we will be cultivating our fields a minimum of five trips; this leaves us ample opportunity to side-dress our plants once or twice to achieve our total of 145lbs of N for the final grow out. Boron has become a big factor in our production the last four years. Carefully testing every year to be sure we keep to our goals, we are now believers in its efficacy. Especially, if the fields next crop is another lover of boron like beets or Celeriac. We apply boron with our boom-sprayer to insure even application and always try to do it just before the last smooth harrowing. To err on the side of caution, we never add more than a 2 lbs. of an active ingredient to any field in any calendar year without another soil test to make sure it is needed.

Transplanting: We use a water wheel transplanter. It is a muddy dirty job but there is no substitute for a well watered-in plug. If the plug is at its peak maturity, it is put in with ample water, and the soil is slightly dry ‘outside’ the wet plug site, we can let the plugs sit two days before we go over them with a blind cultivation fine tine weeder like our Lely. If the gods are with us, not one of them will pop out! Getting to this moment in the life of our Brassica crops is everything! If the plug is too mature the roots will go in circles and not expand out to anchor themselves. If they are too immature, they will just take too long to, again, anchor themselves. The first five days of weed control in the field sets the measure of profitability for all our brassica crops! If we miss our goal it can cost us hundreds of dollars in labor keeping everything weed free.

Cultivation: We blind cultivate (or fine tine cultivate) up to three times, every three days if possible. Next trip utilizes our “two-row Regii Power Weeder”. This slightly hills the soil towards the center of the plug line while power ripping out any weeds that the Lely tines may have missed. Third cultivation is with our J.D. 900HC, a single row narrow tractor that can cultivate a single row on our 36" center broccoli rows. It also has the best side-dressing unit on our farm and feeds both sides of the plant. Fourth cultivation is with our Ford 1710, which straddles the two rows and does under-cutting while drying the soil for the last run through. If everything comes together, we can spend as little as one hour having a crew of three employees hoeing an acre of broccoli.

Spacing: We use 36" between plants but 38-40" between paired rows. We like the extra room to make our differing cultivating systems work. It also helps the broccoli leaves find better light. This year we are using 15" in the row. Next year we will be experimenting with 12" in the row with certain varieties like Arcadia and Gypsy. California gets it down to 9" in the row but they are growing proprietary crown production cultivars not readily available or desirable to East Coast growers.

New Ideas: In an attempt to increase our profitability with broccoli, we are experimenting with a protocol where we first take a shallow crown off the top of the plant. At the same instant, (with our harvest knife) we will cut the next four top leaves halfway back toward the central stalk. We are finding the next four leave sites provide excellent large side shoots! Our retail goal is to get our plant profits up to $6.50 a plant! That is twice the profit of our previous years of over zealous "chop and drop" harvest techniques, which was a reaction to the chain stores demand for banded three-stalk production.

A second idea is to get familiar with growing 'Chinese broccoli'; i.e., Johnny's "Happy Rich" and Snow Seed's "Guy Long". Similarly these plants are grown to that tipping point where they are shifting from vegetative to reproductive growth. If one cuts the top growing point, (at the first sign of floret development) one stimulates side shoot production down below. If your fertility, water and growing temperature are just right you can get an endless supply of broccoli florets that are amazingly tender. This is particularly well suited to mild cool fall production and winter greenhouse production. There seems to be a clear preference of these plants to grow in protected (wind free) environments, which is why we have had our best success with growing these type cultivars in our winter greens houses. Paul and Sandy Arnold start their seeds in January. Plant the plugs in February and harvest the side-shoots for the next seven months!

**Insect and Diseases on Brassica Crops**

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Because of their cold-hardiness, Brassicas are among the first crops to be planted in the spring, and the last to be harvested in the fall. Some Brassicas are planted in multiple successions, while others are long-term residents in the field. Insect and disease pressure often increases over the course of the season. Although a 'calendar' of when to expect which insect or disease varies greatly with the season, thinking of management as a timeline can be useful. This is one crop that also requires regular field scouting, as most problem get their start hidden in the canopy, in and under the leaves, stems and roots.

**Preplant considerations**: *Alternaria* species, downy mildew and black rot can be seed-borne. As growers diversify their seed sources and may save their own seed for certain varieties, the possibility of introducing disease on seed increases. Disease can begin on one variety, and spread throughout the field. Select seed that has been certified as disease-free or treat seed with hot water (15- 30 minutes at 122˚ F) to eradicate pathogens, an effective tool to reduce disease risk and can be done on the farm. Some seed companies will treat on request.

Crop rotation is key with Brassicas as with many other crop families. It is good to avoid letting brassicas become too high a proportion of your crop acreage, as that will make it harder to stay out of Brassica crops for 3 years, which is best. Think not only about between-season rotation but also in-season rotation. Often there are major plantings in spring, and again for fall harvest. Plant these as far apart as possible. Flea beetles, caterpillars, *Alternaria*, black rot, cabbage root maggot fly – all of these have multiple generations; field separation can reduce the pressure on fall crops. Avoid planting onions and fall Brassicas in close proximity to prevent movement of onion thrips into Brassicas as onions decline.

Additional cultural practices for a healthy crop:

- Provide adequate fertility including boron. Brassicas are heavy feeders and often benefit from side-dressed N.
- Adjust planting density to reduce periods of leaf wetness which favor pathogen spread.
- Control cruciferous weeds, which harbor insects & pathogens.
- Select disease resistant cultivars; in broccoli, look for a tight, well-domed head.
- Locate seedbeds, transplant houses, and early Brassica successions so as to reduce the spread of wind-borne inoculum to later plantings.
- Avoid planting in fields that receive run-off from areas previously planted to crucifers.
- Do not locate cull piles near fields, transplant greenhouses, or storage areas. Better yet, compost, bury or remove all culled plant material.
- Let fields dry out before cultivating or harvesting.
- Use drip irrigation instead of overhead irrigation.

- Promptly and fully incorporate crop residues after harvest (in reduced till: mow, plant cover crops.)

**Flea beetles:** Beetles overwinter as adults in field edges near their fall feeding sites. Adults become active on the first warm days, and locate seedlings with uncanny speed and accuracy. They prefer *Brassica rapa* & *B. juncea* crops such as tatsoi, mizuna, bak choi, and mustard, but will also feed on the more waxy *Brassica oleracea* crops such as broccoli, cabbage, kale and collard. The crucifer flea beetle (*Phyllotreta cruciferae*) is uniformly black and shiny, about 2 mm in length, while the less-common striped flea beetle (*Phyllotreta striolata*) has two yellow stripes on its back. Egg, larval and pupal stages are hidden from sight, underground in the root zone, but the peak of adult feeding in late July and early August is due the emergence of a new generation from the soil. These adults feed heavily, may lay more eggs, and depart for field edges in Sept. If you see a third flush in September, this is likely a second generation emerging. **Row covers.** Floating row cover provides the most effective protection from flea beetles, especially in spring and early summer. It is expensive in materials and time, but it works and is widely used for salad mix. It is critical to seal the edges with soil or bags on all sides immediately after seeding or transplanting. Hoops are not needed. The cover has to be removed for cultivation and replaced the same day. 'Non-heating' insect barriers can extend this tool into the summer months but do not use over established crops because aphids are trapped in and beneficials are excluded. Flea beetles require a fine mesh, though not quite as fine as thrips. Fall turnips tend to produce distorted roots when grown under row cover. **Chemical control**. With foliar sprays, even if good control is achieved, re-infestations can occur rapidly and require additional sprays. Several pyrethroids, carbamates and neonicotinoids are labeled for flea beetle in Brassicas. Avoid repeated use of one type of chemistry over multiple generations or using both soil and foliar applications of the same group. Soil-applied systemic insecticides such as Admire Pro and Actara can provide longer term control against damage, although beetles may be present when scouting. Watch longer days to harvest intervals. For organically managed fields, efficacy of spinosad is well documented and it has a longer residual (5-7 days). Pyrethrin often shows poor efficacy in trials but does cause significant short-term knockdown and is a key alternative product. Kaolin reduces feeding damage and can be used early in crop growth before marketable leaves are present (cotyledons & young seedlings in direct seeded, young transplants) and it offers an affordable alternative product. Any of these can be mixed together. **Trap cropping:** Planting preferred hosts (*B rapa* and *B juncea* crops) to protect less preferred hosts (some *B napa*, all *B. olercaea* crops) works by concentrating adults in the preferred crop where they can be sprayed. Unsprayed traps have also been shown to reduce feeding on less preferred neighbor crops. Mixing trap crop species may work better than one species. Border trap crops help intercept incoming migrations, but strips within the field can also serve to collect higher numbers. Scout both 'trap' and 'main' crops to determine when sprays are needed in each. With timely, targeted sprays, 'trap' crops (eg bok choy, Chinese cabbage) can be fully marketable while also serving to reduce sprays on the 'main' crop.

**Cabbage Root Maggot (***Delia radicum)***:** After spending the winter as pupae underground, adults emerge at the same time that yellow rocket weed blooms (late April to mid-May) and search out the earliest Brassica plantings. Temperature models, yellow sticky cards, and close-up field scouting for eggs help growers know when this fly is active. When leaves turn red, plants wilt and stop growing, or collapse completely it is a sign that larvae are feeding heavily on roots. Currently, insecticide chemistry is limited to organophosphates which are banded over the row, and resistance has become a problem. Rotation, row covers, later planting dates, and cultivation that throws soil around the stems to encourage secondary root growth help reduce losses. Predatory nematodes (*Steinernema feltiae*) applied to transplants are a biocontrol option.

**Imported cabbageworm and diamondback moth.** The first to appear is *Pieris rapae*, the white cabbage butterfly that lays eggs singly on the leaves. There are 4-5 generations of imported cabbageworm (ICW) per year. In the past, these built up over the season but now they are kept partially in check throughout the Northeast by *Cotesia rubecula*. This parasitic wasp was introduced in 1988 and lays its eggs in small larvae. After killing its host, the immature *C. rubecula* spins a 2 cm long white cocoon. Diamondback moth *(Plutella xylostella)* appears in late spring or early summer, is smaller and wiggly when touched, causes small, round holes that tends to be spread across the foliage, as opposed to ICW, which feeds primarily in the plant center and the head. Both are best monitored with direct scouting of under the leaves. The most critical time for scouting and applying controls is just before heads form, but leafy greens should be checked throughout their growth.

**Cross-striped cabbageworm** (*Evergestis rimosalis*) builds in midsummer and is something new to watch out for. It has not historically been found in New England but has gradually extended its range northward. We first listed it in the New England Vegetable Management Guide in 2005, because it had become common in Connecticut. In 2012 it was found in Hampshire, Worcester and Norfolk Counties in MA. One of the major differences between this insect and the other Brassica caterpillars is that the eggs are laid and caterpillars feed in a group on one plant so that it's covered with big holes like buckshot. This moth is closely related to European corn borer, and the adults are similar in shape and coloring – straw-colored with a little purple and crossed by wavy lines. Since it flies at night, you will likely only notice the caterpillars and their damage. The clusters of 3 to 25 eggs are yellow, flattened, and attached to the lower leaf surfaces. The caterpillars are light bluish-grey on top and green underneath, with numerous black transverse bands across their backs and a yellow line down each side. Larvae grow to 3/4" long in 2 to 3 weeks. There are 2-3 generations per year, but generally it's only in late summer that numbers reach damaging levels. Larvae can produce small holes in leaves until only veins remain, feed in terminal buds and sprouts, or burrow into heads. Plants with larvae are often completely skeletonized. Adjacent plants may be left undamaged. Selective insecticides such as Bt's and spinosyns are effective.

**Black Rot of Brassicas,** *Xanthomonas campestris* pv. *campestris*, is a bacterial disease that plugs the water-conducting tissue of the plant with xanthan, a mucilaginous sugar. It usually develops after warm, wet weather in midseason, but can occur earlier. It can explode after heavy rains. The optimum temperature for the pathogen to grow is from 80ºF to 86ºF. Water, in the form of rain, irrigation, or dew, is required for the disease to establish, grow and spread. Symptoms appear as yellow, V-shaped lesions that extend from the leaf margin toward the base of the leaf, resulting in wilt and necrosis. It can also occur mid-leaf, as darkened dead patches of tissue between the veins. Symptoms on root crops may not be visible on foliage, but blackened veins appear in the roots. On heading crops, infection may spread into the leaves of the head. **Spread.** The most important means of transmission is in seed, and as little as 0.03% infection can cause epidemics. Surface treatment of seed is not sufficient; hot water treatment reaches bacteria under the seed coat. The bacteria can persist in infected plant debris for up to two years, especially in cabbage and Brussels sprout debris; it survives on its own in the soil for 40-60 days.

Infected seedlings may be symptomless, allowing infected plants to be transplanted into the field or transported to new farms. It is favored by warm temperatures and spread within the field by splashing water, wind, equipment, people, and insects. **Chemical control**: Copper products are most effective when used before infection is widespread and with continued sprays at 7-10 day intervals after symptoms develop. It can't cure an existing infection, but it may slow it. Aim for good coverage of lower leaf surfaces.

**Cabbage looper *(Trichoplusia ni)*** arrives in migratory flights from farther south and does not show up until late July or August, though some years they are not found at all or earlier flights occur. Adult moths fly at night and are rarely seen unless monitored with pheromone traps. Caterpillars are light green, with wavy white or light yellow lines down the back and sides, reach 1.5 to 2 inches and make ragged, large holes in foliage, on both frame leaves and heads. They also feed in lettuce, chard and spinach. Controls are the same as for ICW and DBM.

**Alternaria leaf spot** is a fungal disease that affects all cultivated brassicas, causing small black spots that grow into large lesions with characteristic concentric rings on leaves, stems and heads. The most damaging Alternaria species in Brassicas are *A. brassicae* and *A. brassicicola*. Disease development is favored by cool temperatures (60-78° F) and long periods of leaf wetness or high relative humidity (12 hours of RH> 90%), thus it tends to become especially damaging in late summer and fall crops. The main means of introduction into new areas is on infested seed (remedied by hot water treatment and seed fungicide treatements). Once established, *Alternaria* species overwinter primarily in diseased crop debris. Spread from one infected crop into nearby crops occurs easily, as the fungi sporulate profusely and are moved by wind, splashing water, equipment, and workers. Manage with cultural controls, resistant varieties, and preventative fungicides. Biological disease control products are being studied at UMass and Cornell.

**Onion thrips (***Thrips tabaci***)** are most likely to build up in fall Brassicas after onion crops reach maturity. Their rasping mouthparts open wounds on the undersides of leaves, causing raised brown scars. This may also occur within cabbage heads; some varieties are more resistant. As with most diseases and insects in Brassicas**, scouting the undersides of leaves is critical** in order to catch and manage this problem. Spinosad (Entrust and other products) and spinetoram (Radiant) are effective.

**Downy Mildew of Brassicas** can affect any crop stage and may spread from seed, infected living crops & weeds, or long-lasting resting spores. Disease development is encouraged by cool, moist conditions. Infections on seedlings and transplants can become systemic and dormant; returning later in the field when conditions are favorable and decreasing crop yields. Winter greenhouses can be conducive and can be a living bridge. Strict sanitation, rotation, weed control, environmental management in the GH are critical as chemical management is not sufficient for this increasingly common disease.

**Swede Midge** is established in Northern Vermont, western NYS, Quebec and Ontario and causes severe damage to head and stem Brassicas in those areas. Adults are active all season long. Row cover, long-distance rotation, timing, and insecticide applications are current management options. Get to know what to look for, and see resources http://web.entomology.cornell.edu/shelton/swede-midge/.

## Strategies for Continuous Production of Summer Salad Greens/Leafy Greens

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### Field Prep

Field preparation for leafy greens begins the year before production with cover cropping and summer tillage to reduce weed pressure during the crop year. Typically a full cover of winter rye and vetch is incorporated in mid June to mid July and a summer bare fallow is maintained to diminish the weed seed bank. In mid to late August a fall cover of oats are seeded, which are winter killed, leaving a light mulch the following spring. This mulch is either disced or shallow plowed (3-4") to create a seedbed for spring and summer planting.

### Planting Schedule, Lettuce

Lettuce makes up approximately half of our mix and is both transplanted and direct seeded. Transplanted lettuce varieties are the salad bowls and oakleaf varieties, which have deeply lobed leaves and don't appear to be a large torn up leaf when harvested at a more mature stage than baby lettuce. This has a number of advantages: first we can achieve a steadier supply of lettuce during the growing season as germination and early growth of the lettuce is accomplished in a controlled environment. Second, weeds are more easily controlled around transplants than direct seeded plants. Third the bulk of leaves harvested from transplanted heads are greater than direct seeded leaves and fourth the frillier mature leaves add volume to the mix with less weight.
We additionally direct seed lettuce for our mix as it adds variety and texture to the mix. For direct seeded lettuce we use a three-row Planet Jr. Seeder with one lettuce variety per row. Lettuce mixes are not used. The main reason for this is that different lettuce varieties have different growth habits and dates to maturity. With the varieties separated we are able to cut each variety at its optimum stage. Lettuce is seeded and transplanted on a two week schedule and harvested two to three times.

### Planting Schedule, Greens

Salad greens; Arugula, Red Russian Kale, Red Mustard, Tatsoi and Mizuna; are seeded weekly. These greens are seeded separately in a double row using a two-inch scatter shoe on the Planet Jr. Floating row covers are installed over the greens before germination for control of flea beetles. Since these beds are covered, early weed control in the greens is essential. To accomplish this the greens bed is prepped two weeks prior to seeding. This includes bed forming, rotovating and incorporating a combination of bloodmeal and soybean meal and rolling the bed to allow good soil contact for weed seed germination. On the day of seeding the bed is flame weeded prior to seeding to eliminate any germinated seeds. Floating row covers are applied using a set of disc hillers on a toolbar, which also rolls out the fabric. Agribon 15 or 17 in a 72-inch width is preferred, as these fabrics don't retain as much heat in the summer. No hoops are used when the fabric is first installed and edges are buried in soil to seal the bed. Approximately two weeks after seeding one side of the row cover is lifted, the bed is hand cultivated, wire hoops are installed and the fabric is again sealed with soil using a high wheel cultivator and a plow attachment. We have found that weeding can be significantly reduced with the earlier seed bank reduction and flame weeding. In the early season when flea beetle damage is highest we have sprayed through the row cover to control beetles that moved in while the bed was uncovered.

**Harvest**

Harvest was done twice per week with a goal of 100-120lbs. per harvest. A work crew of 6-7 could cut; wash, bag and pack 100-120lbs. of greens in four hours. Sales were to local restaurants and natural food stores and averaged $8.00/lb. for salad mix and $9.00/lb. on arugula. All cutting was done with sharp scissors, by handfuls into washable plastic baskets. Lettuce heads were cut to retain the growing tip for future harvest. Direct seeded lettuce and greens were seeded in rows to allow for efficient hand cutting. In order to reduce decisions on the salad mix ingredients during cutting, plantings were done in approximate quantities needed for sales. While a lettuce planting was often harvested 2-3 times, greens were only cut once.

- Transplanted lettuce, grown four rows per 100' bed would have a double row cut each harvest day. Yields averaged 45lbs./100' double row.
- Direct seeded lettuce, sown three rows per 100' bed would be harvested at 1/2 bed per harvest. Yields averaged 15lbs/1/2 bed
- Arugula, grown two rows per 100' bed, had one row cut each harvest day. Yields averaged 25-30lbs/100'. For a 120lb. batch not all of this was needed allowing for additional sales of arugula.
- Other Greens: The standards here were Red Russian Kale, Mizuna, Red Mustard and Tatsoi as these ingredients consistently averaged the best yield. Grown two rows per 100' bed with one row cut each harvest day, yields averaged 30-40lbs./row, also allowing for additional sales. Other greens, such as beets and spinach were added when available.

Salad mix sales grew to be the largest grossing crop produced on our farm, with sales accounting for 50 to 60% of the business. Timing, weed control and efficient harvest strategies reduced the overall workload and allowed for successful summer production.

**Stay Small & Turn Up the Awesome!**
**Making a Living on 2 Acres in Burlington, VT**

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## Summary of Presentation

We have owned and operated Half Pint Farm, a two acre farm growing baby and specialty vegetables, in Burlington's Intervale since 2003. We have been operating successfully for over a decade, and we are happy to share some of our personal and business philosophies that have made us profitable enough on our two acres that farming became our main source of income after year 5, and our only source after 2011, and we are able to take winters off.

## Personal Goals with Farming

When we set out to start our farm, certain things were very important to us:

- We wanted our farm to fill a local need/niche and not duplicate other efforts
- We wanted our farm to be profitable
- We wanted our farm to be inspiring
- We wanted to wake up loving what we did every day
- We wanted to work together
- We wanted to prove that small acreage vegetable cultivation could be profitable

Farming was a way for us to explore larger ideas and engage with our community in a very real, concrete and helpful way. Mara majored in physical anthropology at the University of Colorado and was interested in interacting with people in a way that reaches back to an ancestral, archetypal relationship between land, food and community. Spencer majored in classical languages at the same school and was interested in the Roman authors of farming manuals and the historical claims that veterans of the Roman Punic Wars were given a parcel of roughly 2 ½ acres in payment for their military service. Additionally, we both gained an appreciation for good food and found ourselves seeking better and better ingredients as we learned more about cooking. In many ways, the farm we set out to create for ourselves was meant to be a cross between a Roman peasant garden, a gourmet food source and our own little part of the shire from Tolkien's The Hobbit. What Half Pint Farm has been providing us for the past eleven years is a real way to share our passion for growing specialty produce and sharing preparations with our customers to maximize the engagement with and ultimate appreciation of those products.

## Professional Goals with Farming

It was very important that we were profitable. We recognized that we couldn't do it all at once and so we ramped up land use and production gradually over a 5-year period until we were at the level that we are today. Before we started our farm and during the first several years, we read many of the books that are out there as resources for organic farmers. Many of these books focus on the vital practices of soil fertility, crop rotation and weed control. We found that if we tried to focus on perfecting our own systems for optimal soil health, we did not have the skill in the early years to also harvest, handle and market the produce we could grow for enough profit to keep us in business. We decided to put our greatest effort into marketing the produce for the highest price we could get, rather than focus on attaining the greatest yield possible for each individual crop. This meant cultivating the relationships with our customers, both at the farmers' market and with restaurant chefs, with more attention than cultivating the soil and the plants. This did not mean we neglected or mistreated the land we worked, but we have been lucky to have such excellent soil (Winooski type very fine sandy loam) that it did not take excessive attention. Consequently, our goal for the first five years was to become sustainable financially with the two acres under cultivation. For the subsequent six years we have been able to focus more on becoming better growers and stewards of the land, while continuing to maintain or grow our annual income.

## The Numbers

We started our farm growing only one about ¾ acres. We farm in Burlington's Intervale which is a floodplain in the city limits that supports a community of farmers who operate separate businesses, but share equipment including tractors, heated greenhouses and walk-in coolers. Because of this community, we were able to start our farm business with a $3000 cash advance from one of our credit cards. We have set a financial goal for our yearly gross income each year we have operated the farm starting in the first year when the goal was $10,000 revenue for that year. Currently, we grow on a rented parcel of three acres with about two of those under cultivation and our goal this year was $150,000. We met that goal by the middle of October.

We have consistently met or exceeded our goals each year, falling short only when our season was prematurely cut short by flooding associated with tropical storm Irene in 2011. We extrapolate our annual goals into monthly and weekly goals and track them using sales figures entered into an Excel spreadsheet. This way we reduce stress and marital strife by knowing how the year is going with real and up-to-date numbers. We are also able to change how we plant, market and sell our produce each week if the numbers are different than what we project in our goals.

## The Farming Part

We have often commented to ourselves that we share more cultivation techniques with gardeners than with many farmers that we know. We do most tasks by hand including transplanting, weeding and harvesting. We follow most organic standards, including fertilization and pest control products, but we are not a certified organic farm. We make a lot of use of landscape fabric for weed control in our long term crops including peppers, tomatoes and summer squash. The rest of our weed control program is focused on hand- and hoe-weeding. We have one unheated 17 foot by 96 foot, four season hoophouse that we use exclusively for growing cherry tomatoes and we have a half-acre Haygrove brand high tunnel that we plant with tomatoes, squash, beans, carrots and salad throughout the summer. These structures give us about two weeks of season extension on either end, but are mainly useful in keeping the rain off of our crops. We both share a dislike for spending time using and fixing tractors, so our primary cultivation machine is 732 BCS walk-behind tractor with a 30 inch rototiller. We use the shared tractors for about 20-25 hours per year.

We employ one full time worker, one part-time worker and have three or four free workers help us for six hours once a week. As the owner/operators, we each work about 60 hours a week from April through October, taking Sunday and parts of Monday off. The majority of our time and labor during the summer is spent harvesting, washing, packing and marketing our produce.

## The Selling Part

This is our bread and butter and where we make money on our crops. We spend a lot of time choosing the crops that we think are unique and in-demand. Because we direct market almost all of our produce, we are able to build demand for products we are excited about, even if our customers are not yet familiar with the specific varieties. We have built an effective ecosystem of markets over the years in which local chefs visit our stand at the farmers' market to see what new and exciting varieties we have, and then take them to their restaurants to work with. Our customers eat at these restaurants, try the new crops and then come to market to find the ingredients to try making the dishes themselves. Mara works closely with the chefs, often in their kitchens or alongside them at special events, and so has become acquainted with what they look for in vegetables and what they get from other vendors. We also track food trends, so that we can converse knowledgably with the chefs and home cooks as they read recipes in magazines and newspapers. Our market stand has become known for our colorful displays of specialty vegetables and our expertise in helping our customers make the most of the produce we sell. This is the part of the work we both enjoy the most and our interactions with our customers show this enjoyment. Our limited quantity of product has also helped us to maintain a fair, and fairly high, price that our customers are willing to pay. We are able to sell to the most enthusiastic buyer and are never driven to offload excessive products at low prices. We consider this to be the most important leverage point in our ability to make our small size farm profitable.

## The Take-Away

Our customers aren't just buying veggies – they're buying a piece of us. Authenticity, earnest interest, and high quality really get this message across to our customers, making them come back week after week. We have tried to tailor our small farm to both our own individual goals and our personalities and temperaments. The overall goal of our farm is to both provide us with a living and a lifestyle that we can enjoy, and to act as a tool to engage with our community in a constructive way. We have found our scale of farm succeeds in these goals so far. We also find that the small scale allows us some flexibility as we consider what goals we have for the future as we look to continue to dial up the level of awesome on our two acres.

## Tools and Techniques for Transitioning from Small to Large Scale Vegetable Production

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In 2002 we started our farm with a ¼ acre garden plot, a walk-behind rototiller, rakes, hoes, earthway seeder and garden sprinkler. We sold our produce during the summer on a plywood table by the road. Employees: 3 very part time. Sales were about $7000.

In 2013 we farmed 20 acres of mixed vegetables, selling primarily through our Year-round CSA, farmers market, farmstand and wholesale accounts all within 25 miles of the farm. Along the way we have upgraded our tools and techniques to scale up vegetable production and markets. Today we have 2 heated greenhouses and 7 unheated high tunnels. Employees: 5 full time; 7 seasonal. Current sales (including livestock, poultry and eggs) are around $700,000.

**How did we get there from here?**
As we scaled up in production we increased our markets – marketing was and is the key. As we have grown our markets we looked for areas to mechanize and become more efficient and keep crew morale high in the fall after a long season. These factors led us to purchase the tools we use today.

Some of the most profitable crops for us are the ones that are precision seeded, little weeded, and harvested mechanically (salad greens and root crops). As a result we are growing more of these crops.

**Mechanical Harvesting – what is the payoff?**

Greens harvester
Our walk behind greens harvester can cut greens grown on a 44 inch bed top, it is used year round – in hoophouses too. Cutting greens by hand it takes 5 hours to harvest 100 lbs. of greens, with the harvester it takes 20 minutes (including setup of harvest totes) – this is a fifteen-fold reduction in labor. Harvester cost $7000 used, paid for itself in labor savings after harvesting 14000 lbs. greens – at our level of greens production this means it paid for itself in about 16 months.

Roots Harvester
Our carrot/beet harvester can mechanically harvest about 1 acre/day. This is expected to increase as we move to harvesting directly into bins. Harvester cost $8000 used, payback is immediate for crew morale as they enjoy working on it and are not beat from dragging bags of roots through the fields in cold fall weather.

Key lessons learned:

1. ID bottlenecks in systems and problem solve to reduce/remove them
2. Reduce handling/lifting across the board for every task!
3. Its all about materials handling – see no. 2

**Tools Today at Jericho Settlers Farm**

| | |
|---|---|
| Tractors<br>Massey 65 2WD – 50 hp<br>Kubota MX5100 4WD – 50 hp<br>Kubota 8540 4WD- 85 hp<br>Kubota L245H – high clearance offset cultivating (three of these)<br>Allis Chalmers G – (two of these mounted with budding basket weeders)<br>Farmall Cub – (3 of these for cultivating and side dressing fertilizer) | Tillage<br>3 bottom plow<br>6 ft disc harrow<br>6 ft roller harrow<br>48" Kuhn rototiller<br>13 foot Perfecta harrow<br>4 shank chisel plow<br>3 shank subsoiler |
| **Bed shaping**<br>Rainflo plastic layer<br>Lesche bed shaper<br>48" Kuhn rototiller<br>Rainflo tunnel layer | **Cultivation**<br>Lilliston cultivator<br>2 Buddingh basket weeders<br>Cultivating shovels, discs, spider wheels<br>6f t Lely tine weeder<br>2, two row potato planter<br>Homemade flame weeder on 3pt |
| **Planting-Seeding**<br>Earthway hand push seeder<br>Planet jr hand push seeder<br>Planet jr 3pt seeder<br>Rainflo water wheel transplanter<br>Grain drill for cover crops<br>Cone seeder<br>Rainflo 3 pt bed marker<br>Sutton Ag seeder, 3pt | **Fertilization**<br>EZEE flow bed fertilizer<br>Cone fertilizer on Kubota L245H and farmall cub<br>**Mechanized Harvesters**<br>Greens Harvester, 51 inch cut width<br>Scott – Viner Carrot/Beet Harvester<br><br>**Other harvesting tools**<br>3 pt Undercutter bar |

| | |
|---|---|
| **Greenhouses**<br>1 heated seed starting greenhouse<br>2 heated winter growing/early tomato houses | **Hoophouses**<br>6 fixed hoophouses<br>1 mobile hoophouse |
| **Wash/Pack**<br>Grindstone Barrel Washer<br>Brush washer, conveyor, sorting table<br>Stainless steel tanks and tables<br>Rubbermaid tanks<br>Wash machine for spinning greens<br>Pallet jack<br>Field Bins<br>Walk in freezer | **Other**<br>Onion topper<br>Irrigation reels<br>Overhead hoophouse irrigation<br>Driplines<br>Solo backpack sprayer for pest sprays |
| **Refrigeration**<br>5 walk-in coolers<br>walk in freezer | **Warm storage**<br>For squash, sweet potatoes, etc. |

**Farm Decision Making**

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Kilpatrick Family Farm is a mixed vegetable, fruit and poultry farm located in Middle Granville, NY zone 4b. The majority of our sales are through a 200 member CSA as well as several farmers' markets in Saratoga Springs and Glens Falls, NY. We also sell a limited amount of items wholesale through Co-ops, restaurants, and to other CSA's. The farm is approximately 500 acres of owned, rented and leased land, 40 tillable acres, 100 pastured acres, and the balance woodlot and scrub. We plant between 12-14 acres of vegetables and fruit every year.

Early on in our farming career, we knew that we needed to make a plan, and then work towards that goal. Thus, every year, we start with a strategy session. We lay out what our idea of what the next 3 years will look like. We look at our current markets, what is changing, and how we are going to change our business based on those factors. We create several scenarios and directions the farm could go, analyzing the land base it would necessitate, the equipment and personnel that it would require, and how every aspect would fit into our life and farm vision.

Specifically, in regards to marketing, we cost out all our expenses for each channel. For example, CSAs have to cover our CSA coordinator's salary, brochures, and any expenses specific to the CSA. A Farmer's market has to cover the fees of that market, the mileage, the employees that staff the market, etc. Even though our wholesale orders are on the same truck as our farmer's market, it is still responsible for its own mileage.

Kilpatrick Family Farm is made up of 6 different rented/leased properties. Therefore, when analyzing land acquisition, we are looking at several qualities: 1. Soil type, quality, and track size. 2. Water availability. 3. Proximity to current worked properties. 4. Track record of landowner - we vet them seriously. 5. Security of land i.e. is it fenced, gated, or would that be easy to accomplish. Our goal is for at least a 5-year, rolling lease, but we will sign as short as a 3 year rolling lease if the land scores very high in all other categories. We only use the soil maps as a resource, and check the property thoroughly ourselves.

We make a list of the equipment we are looking to buy that year, as well as the next year. If we are going to buy it new, we make sure to order it during the winter with plenty of lead time so that we can get it set up and tested before the busyness of the season begins. Other equipment we watch for and then buy when the right machine comes along. We maintain a 5-10 K rainy day fund for equipment that might not be on our current list, because sometimes a good deal may become available and is too good to pass up. We check places like Craigslist, eBay, machinefinder.com, tractorhouse.com, and other known equipment clearinghouses on a regular basis.

We try to make sure that any equipment that we buy is multi-use. For example, several years ago we bought a hi-wheel JD tractor. It was great for the few things it did but way too specialized for the size of our farm. We ended up selling it at a loss. Another example is the vegetable washer we bought this year. Not only does it wash our tomatoes that it was purchased for, but peppers, eggplants, squash, cucumbers, melons, and new potatoes, making it well worth the money we spent on it.

As we are making decisions on the farm we are constantly asking these questions:

How does this fit with my long-term plan?

How many hours will this save us? Cost us?

How does this affect, me, the farmer?

How does this affect our crew? What do they think?

How does this affect the farm financially, or what are the long-term liabilities of this decision?

How does this fit with our systems already existing on the farm?

Do we have the money for it?

What additional expenses, resources, or time commitments will this purchase/lease incur?

What are the numbers on this? Payback, reduced cost per unit of crop, etc.?

What do councilors or mentors think?

What do other farmers using this piece of equipment, technique, or soil type think of it?

## Technology and Methods to Making Scaling Up Profitable and Labor Efficient

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My partner Melody Horn and I farm 30 acres of vegetables and flowers in the Adirondack Park of upstate NY. We distribute through a 300 member CSA, 6 farmers markets, and wholesale to various businesses.

**Do the work yourself:**
I was raised in a very handy family and my father always did 100% of his own work, from carpentry to mechanics to refrigeration. Farming is the most challenging occupation I know. For this reason I do all the work myself and with my crew members because under no circumstance is pouring concrete, completing electrical connections, excavating a hole, or building a barn more challenging. You may perceive this as hard as someone else makes it look easy but farming is outright the most challenging occupation we can choose.

I have had much opposition to this point of view in which people tell me if I concentrated on farming I could afford to hire someone to do these other projects, and that's when I started to get estimates from "experienced contractors" and then figured I could do it wrong three times for the price of them doing it right. Fortunately it never took more than the first time to make it acceptable. Half the time I feel these experienced contractors are flying by the seat of the pants as much as we are when we try a new variety of vegetable, so I'll continue to take my chances.

**Welding:**
One of the first items I wanted to learn was welding, so I took a $400 class at my local adult education center. This single class outright changed my world and I recommend it to everyone. From that class the possibilities of machinery became endless.

Farm Hack is a community of farmers, engineers, welders, etc… all coming together to see if we can build more efficient scalable tools for our farms.
To Date we have constructed: A basket weeder, Perfecta II, Waterwheel Transplanter, Bed lifter, various toolbars, mulch lifter, liquid propane flame weeder, belly mounts for a Kubota L245H,

**Energy Conservation:**

In NY we have an Agricultural Energy Efficiency Program through NYSERDA. Other states have similar programs. These programs are designed to make your operation more efficient; that being said, NYSERDA only covers efficiency upgrades for Electricity and Natural Gas. They come do an energy audit and make some assertions. In our first AEEP we had 6 LED grow light financed and $2500 worth of lighting for our wash shed, shops, and work areas.

We also started heating with waste oil. At $3+ per gallon the cost of using waste oil/veggie oil can pay off pretty quickly. All our slabs and greenhouses are heated with two boilers that run on what we collect from our restaurant routes.

**CSA:**
With a grant from Cornell and a need for a larger membership we started developing worksite CSA's throughout our region. Our big selling point is a fully customizable share with meat, dairy, and eggs from other farms delivered right to their place of employment. Remember there are a lot of consumers that cannot make it to your farm or to the farmer's market. Fortunately the majority of them are required to go to work. We manage this through a system called FARMIGO. Yes they take a percentage of our total, and yes I hate like hell giving them that percentage, but until someone helps me get to another means of offering a customizable share that's what I got.

After five years flying by the seat of our pants 2014 will mark the first year we have an actual plan for our business, with the help of our county business services etc… we will see how it all turns out. I wish I could say where we are right now was all planned, but it has been quite the opposite.

## New Innovations in Pumpkins

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The ornamental pumpkin acreage North America expanded considerably between 1980 and 2000, with the larger pumpkins in the 12 to 25 pound range having the largest contribution increased sales. Expansion in the 21st century appears to be more in terms of variation in types of pumpkins. One of the first of the novelty types was that of introducing the warty trait into large pumpkins. Our focus at UNH has been to introduce novel color types into new varieties. For example, medium size pumpkins with white rind and good robust handles were non-existent up to 2009. We have developed the variety Moonshine to fill this void. Our immediate improvement in the Moonshine variety will be to release a Moonshine hybrid with intermediate powdery mildew resistance (PMR). Next we plan to develop more size variability in the white pumpkins. A new introduction with limited seed availability this fall will be a yellow pumpkin, Sunlight', which will be in the small pumpkin class and also have PMR. A larger yellow pumpkin will soon follow that introduction in the coming year or two. Finally, we currently have another long-term project to develop different striping patterns into pumpkin.

## Effects of Fungicide Timing and Tillage on Powdery Mildew Resistant Pumpkins

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**Introduction (Current Fungicide Program).** Before I can talk about this experiment, I need to remind you of how and why we use specific fungicides on pumpkins. I've talked about fungicide sprays on pumpkins before and mentioned how there are four annual diseases that we can protect our pumpkins from with fungicides: powdery mildew (PM), Plectosporium blight (Plecto), black rot (BR) and Downy Mildew (DM). We tend to design a fungicide spray schedule around PM, which is the most common disease on cucurbit crops and often the first to show up. The basic idea is to slow disease spread with the fungicides by limiting spore formation, new leaf infections, and stem and fruit problems, so that you maximize your yields and net profits.

Systemic fungicides, which move through the plant, usually provide the most effective control of PM because it is impossible for any sprayer to provide good coverage where the infection first occurs; on the underside of the lower, older leaves, in a waist-high pumpkin patch. As part of our PM resistance management strategy we use each systemic family only one time each season. That's because, unlike with protectant fungicides, that have several modes-of-action to stop infection, systemics tend to have a single mode-of-action which is easily skirted by the billions of spores that are encountered after each spray. We also add a protectant fungicide to the tank mix during each application to help slow resistance, and to provide control of Plecto and BR on fruit. So our spray program in recent years has gone something like this: ***Quintec + Bravo (i.e. chlorothalonil), Procure + Bravo, Pristine + Bravo, and then we switch to two protectants for the remainder of the sprays (sulfur + Bravo).*** You could also mix the Pristine with a protectant such as sulfur or Dithane, to rest the Bravo, while still providing good protection against PM, Plecto and BR. In 2013 a new systemic product called Torino was registered for pumpkins and should be applied with Bravo for the first application, followed by the schedule listed above. An additional product that works on water molds may be added to the spray mix late in the season if or when DM shows up, but we will talk about applications for water molds another time.

To determine when to make the first application, scout 50 lower leaves each week after the plants run, and spray when you find the first small, round, colony of white powdery mildew spores (usually on the underside of the leaf). Then, we usually continue to make applications at 10-day intervals until mid-September.

**Spray Interval and Tillage Experiment.** Now that you remember the fungicide program, here is the "spray interval" experiment that we ran at the UConn Plant Science Research Farm in 2011 and 2012. Our starting hypothesis was that *with a resistant pumpkin variety, you should be able to stretch your spray interval and still produce marketable pumpkins*.

We used a split-plot design with 2 tillage methods and 4 spray intervals, and replicated the 15' X 40' plots 4 times each, for a total of 32 plots in each experiment. We planted 3 rows of pumpkins per plot that were spaced 5 feet between rows and 2 feet between plants in the row. Half the pumpkins were planted on conventionally-tilled strips prepared with a plow, harrow and cultipacker, while the other half were planted on a narrow (8"), deep zone tilled seedbed through a killed rye cover crop (Fig 1.). The spray interval treatments consisted of no spray, 21 days, 14 days and 10 days.

Fig. 1 Conventional tillage and rye-mulch strips for DZT

In 2011, we conducted two similar but separate experiments with different PM-resistant pumpkin varieties: 'Gladiator' and 'Magic Lantern'. In 2012, we ran a single experiment with Gladiator. Pumpkins were planted on June 6, 2011 and June 8, 2012 and harvested September 12 and 16 the first year, and September 7 the second year.

The first spray for PM was applied on August 12, 2011 and on July 27, 2012. The same sequence of fungicides mentioned above was used in each treatment, except that we used the chlorothalonil brand Initiate instead of Bravo. We did not complete the sequence of 3 systemics + protectant applications before harvest for the 21d treatment either year (only two applications were made to these plots). In 2011, total rainfall for the year exceeded 63 inches in Storrs, with the remnants of Hurricanes Irene and Lee adding to the extreme wetness in late August and early September, while 2012 had "normal" rainfall for the season and year (42.4 inches for the year).

Powdery mildew damage to leaves, Plecto damage to vines, and fruit handle damage were rated on a scale of 0-5, 0-3 and 0-5, respectively, ranging from no damage (0) to severe damage [i.e. leaf (5) or vine death (3) or no handle (5)]. The fruit were weighed at harvest and the percent marketable fruit were calculated. A marketable fruit was considered to be at least 3 pounds and have a handle rating of less than 3 (medium to no damage).

**2012 ("Normal" Rainfall Season Results).** There was not much difference between pumpkins grown with the two tillage methods for any of the factors measured in 2012. However, there were big differences between spray interval treatments. The 10d interval (average leaf rating of 2) provided better PM control on the foliage than the 14d or the 21d (rating of 3), which did better than no spray (rating of 4.3). Both the 10d and the 14d spray interval provided better vine protection from Plecto (rating of 0.9) than the 21d interval or no spray (rating of 2). Again, both the 10d and 14d spray interval provided better handles (rating of 0.8) than the 21d interval (1.4), which was better than the unsprayed treatment (2.5), where most handles were not marketable.

Average fruit weight ran about 13 pounds for the 10d and 14d interval plots and about 11 pounds for the 21d and no spray treatments. Almost all (95-100%) of the fruit were marketable for the 10d and 14d spray intervals, while 75-90% were marketable for the 21d interval (90% in the DZT plots), and only 40-50% were marketable for the unsprayed plots. *We could conclude that in a year with normal rainfall, even with a resistant variety like Gladiator, we shouldn't stretch the spray interval to more than 14 days.* Since both the 10d and 14d treatments received 4 applications in 2012, there was no reduction in fungicide use when increasing the interval by 4 days. However, since pumpkins generally yield about 14 tons per acre, at a retail price of $0.50/pound in CT, *you would make $13,300-$14,000 gross profits (roughly $4,760 wholesale at $0.17/lb.) by using fungicides on a 10d or 14d interval, compared with half that amount, or less, if you didn't use fungicides.*

**2011 (Wet Season Results).** I'll shorten the 2011 story by just talking about the percent marketable fruit results, because in the end, that is what will determine how much money you will make from your pumpkin patch. With all the rain in August and September of 2011, improving drainage with deep zone tillage (DZT), and possibly having a rye mulch for the fruit to grow on, made a big difference compared with growing pumpkins on bare ground with conventional tillage.

Between 80-95% of the Gladiator fruit were marketable in the sprayed DZT plots, but only 65-70% were marketable in the sprayed conventionally-tilled plots, while only 50-55% of the fruit were marketable in the unsprayed plots for either tillage method. *This is an increase in yields of 15-25% in sprayed DZT versus sprayed conventionally-tilled plots.* That means that increased yields from as little as 3 acres of retail pumpkins could pay for a new Zone Builder. A 2008 compaction survey showed that this research farm field was one of the few vegetable fields in the state without a plow pan. Imagine how much better yields might be if you were using DZT on a field with a plow pan (89% of CT vegetable fields) and poor drainage.

Ironically, with more wet weather in 2011, there was not a big difference in marketable fruit between the different spray intervals for Gladiator, as long as they were sprayed (15-40% decrease in yield when left unsprayed).

The wet 2011 season reduced yields for Magic Lantern much more than for Gladiator. For the conventionally-tilled 14d and 21d spray interval plots, Magic Lantern only yielded 25-35% marketable fruit, compared with 45-70% for DZT plots with the same spray intervals (a yield difference of 20-35%). For Magic Lantern, both tillage methods yielded 60-65% marketable fruit for the 10d interval, but only 5-15% for the unsprayed plots. *Spray intervals made very little difference for DZT plots, but a tight schedule (10d) made a big difference for the conventionally-tilled plots.* However, the highest gross profit you would have made with this variety, even with DZT, was $9,800 per acre, compared with $13,300 for Gladiator.

***Our final conclusions would be that Gladiator performs better than Magic Lantern in a wet year, it pays to DZT in a wet year, it pays to use fungicides any year, and you probably want to stick with a 10, or at most, 14-day spray schedule even with resistant varieties.***

**Frost Protection Strategies for Strawberries**

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Strawberries, by their very nature of growing close to the soil and blooming in the spring, are at higher risk for spring frost and freeze damage than are other tree and berry fruits. However there are many management tools available to combat these environmental events which I will briefly explain.

Frost /Freeze: A radiation frost occurs on a clear night with calm winds. Heat is lost to the atmosphere with no cloud cover to hold the heat near the fruiting zone. A temperature inversion layer often times exists making it easier to effectively use frost protection methods. An advective freeze occurs on a clear night with winds and temperatures below $32^0$F, no temperature inversion layer exists and makes crop protection more of a challenge.

Critical temperatures: Critical temperatures indicate at what temperature damage will occur after being exposed for roughly 30 minutes. This doesn't mean a 100% loss, but at least a 10% loss. These numbers are also not hard and fast temperatures. There are many variables such as location of the bud/flower on the plant (exposed versus hidden beneath foliage), and weather conditions preceding the frost (cool weather several days in advance can 'condition' the plants to tolerate cooler temperatures). Critical temperatures are one tool used for determining when to begin frost protection measures, along with dew point and the forecasted low temperature.

| **Stage of Development** | **Critical Temperature ($^0$F)** |
|---|---|
| Bud emergence | 10.0 |
| Tight bud | 22.0 |
| Popcorn | 26.5 |
| Open blossom | 30.0 |
| Fruit | 28.0 |

Source: Perry, K.B. and E.B. Poling. NCSU.1986. *Field observation of frost injury in strawberry buds and blossoms*. Advances in Strawberry Production 5:31-38

Effective frost protection methods:
*Site selection:* Whenever possible site the strawberry planting on a slope or on high ground to avoid pooling of cold air around the plants as it settles to the low areas of the field on a frosty night.

*Row covers*: row covers are spun bonded polypropylene and vary in weight from 0.45 oz to 4 oz. Cloth sheets also work for small areas. Research has shown that using two layers of a 1 oz weight row cover provides somewhat better frost protection than a single layer of 2 oz cover, likely due to air between the layers. Heavier covers (3-4oz) work for frost protection but restrict light too much and need to be removed as soon as temperatures are above freezing. Avoid placing plastic over the rows unless it is suspended and will not touch the plants. Wherever the plastic touches the plant – leaf, flower – the plant tissues will be killed in freezing temperatures.

*Over-head watering:* Over-head watering works based on the principle of latent heat of fusion – as water turns to ice, heat is released. This heat maintains the plant tissue at just above freezing. If at any time during the night the water stops while the temperature is below freezing, the process reverses –heat is removed from the plant tissue and the tissue will freeze. To avoid this, watering must continue until the air temperature rises above $32^0$F and the ice has started to melt.

Over-head watering may be combined with the use of row covers or used independently and requires a calibrated emitter system to be sure the required amount of water is constantly being provided. Positives – proven track record of maintaining the temperature of the flower buds above critical temperatures. Negatives – may lead to saturated soils and root diseases; if the water stops at any point when the air temperature is below the $32^0$F the buds will freeze.

*Wind machines:* This method carries an initial high expense but on sites that are frost prone this method will pay for itself. A temperature inversion and wind speeds less than 5 mph are required for this system to be effective. There are several models, mobile and stationary, tall for tree fruits and lower for vegetables and small fruits. Acreage covered varies by model and the strength of the temperature inversion, generally 1 acre – 20 acres. May be used in combination with supplemental heat for large areas, or when the temperature is expected to be down to the low 20s, or with a weak temperature inversion.

*Return Stack Heaters:* Heaters hold approximately five gallons of fuel with 20-40 heaters needed per acre. They are effective when used alone as well as in combination with wind machines. Avoid large fires (bonfires) as these will penetrate the inversion layer allowing the heat to leave the fruiting zone. When that happens, the only place there will be heat is right next to the fire. Light every second or third heater initially and then light the rest. This will allow heat to begin moving through the field without a big burst of heat that may puncture the inversion layer.

# Calibration of Boom Sprayers

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As stated on the pesticide label – the sprayer needs to be calibrated before you spray!

Proper calibration of sprayer equipment is the only way to ensure spray applications are effective, efficient, and economical. Poor spray coverage is the primary cause of reduced spray product performance. Regular care and maintenance will ensure the sprayer is residue-free and serviceable when needed.

A sprayer should never be operated without first checking the calibration for the following reasons:

1. To determine the precise rate of material applied per acre.
2. To ensure each nozzle tip is operating at the manufacturer's specification.
3. To compensate for equipment changes, crop staging, and environmental conditions.

## Calibration Factors Affecting Application Rate

- Ground Speed

A uniform ground speed is necessary to maintain even spray application. The spray application per acre varies inversely with the ground speed of the sprayer. If the ground speed is doubled the application rate is cut in half and as the ground speed is reduced to half, the spray application is doubled. Rate controllers can only compensate for this within certain limits and can sometimes have a negative impact on spray quality.

- Nozzle Flow Rate

The flow rate through the nozzle varies with the tip size, the pressure applied, and the condition of the tip.

## Calibration Notes

Recording your sprayer calibration calculations for future use is important. By having a record, you can compare your sprayer calibration calculations from calibration to calibration. This information can be useful the next time you check the calibration. This recordkeeping is also due-diligence and is important to have on hand if ever a question arises about product residue, pesticide drift, or any other spray complaint.

## A Quick and Easy Method to Accurately Calibrate a Low Pressure Boom Sprayer

**1.** Measure the distance between nozzles in inches. For a boom sprayer that has nozzles placed 20" apart, measure off a distance of 204 feet on a field similar to that which you will spray (e.g., sod, disked, etc.). The correct distance of travel for other nozzle spacings is as follows:

| ***Nozzle Space*** | ***Travel Distance**** |
|---|---|
| 16 inches | 256 feet |
| 17 inches | 239 feet |
| 18 inches | 227 feet |
| 19 inches | 215 feet |
| 20 inches | 204 feet |
| 21 inches | 194 feet |
| 22 inches | 185 feet |
| 23 inches | 177 feet |
| 24 inches | 170 feet |
| 25 inches | 163 feet |

* 340 feet/nozzle space in feet = distance

**2.** Drive the tractor the correct distance shown above and note the exact time in seconds it takes to pass the end points. Make a return pass and check the time again. If the time differs by no more than 2 seconds, average the two times. Repeat if the time differs by 3 seconds or more. Note the engine RPM and gear that were used to make the passes.

**3.** With the tractor in a stationary position set the same engine RPM used in Step 2. Also set the application pressure (30-40 psi) that you normally use and spray water through the broom. Do the spray patterns from all the nozzles look uniform? If not, the tips should be removed and check for wear or blockage. Collect spray at the nozzles when all the nozzles appear to have a uniform delivery at the desired psi. The container(s) should be quickly placed under the nozzle(s) for the exact number of seconds noted in #2 above.

**4.** The ounces collected per nozzle for the exact number of seconds equal the rate of spray per acre in gallons. (Example: If 18 ounces are collected in the time noted in #2 above, you are spraying 18 gallons per acre from that nozzle). Collect from other nozzles and replace any tips that vary by more than 10% (or 2 ounces with the example stated).

University of New Hampshire Cooperative Extension

# Boom Sprayer Calibration Worksheet

***Retain the following information for your records:*** Date ____________________________

Farm ____________________________ Operator ____________________________ Phone ____________________________

Address____________________________ Town ____________________________ State _______ Zip code __________

***Sprayer and Tractor Identification*** Sprayer ____________________________ Tractor ____________________________

***Calibration***

1. Measure the distance between nozzles in inches.

   Distance between nozzles_________ Travel Distance________________

2. Drive the tractor the correct distance shown above and note the exact time in seconds it takes to pass the end points. Make a return pass and check the time again. If the time differs by no more than 2 seconds, average the two times. Repeat if the time differs by 3 seconds or more. Note the engine RPM and gear that were used to make the passes.

   Tractor RPM____________________ Gear__________________________

   Time in seconds – down___________ time in seconds – back____________ Average Time in seconds_______________

$$\text{Miles per Hour} = \frac{\text{Distance in Feet x 60}}{\text{Time in Seconds x 88}} = \frac{(\_\_\_\_\_\text{ Feet) x 60}}{(\_\_\_\_\_\text{ Seconds) x 88}} = \_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_ \text{ MPH}$$

3. With the tractor in a stationary position set the same engine RPM used in Step 2. Also set the application pressure (30-40 psi) that you normally use and spray water through the broom. Collect spray at the nozzles when all the nozzles appear to have a uniform delivery at the desired psi. The container(s) should be quickly placed under the nozzle(s) for the exact number of seconds noted in #2 above.

   Pressure _________PSI

   Number of Nozzles on Boom___________

   Type of Nozzle____________________

   Size of Tip ______________________

   Height of Boom from Target ___________

   New Nozzle Tip's Output ____________

| Nozzle Output | | | Nozzle Output | | |
|---|---|---|---|---|---|
| Nozzle # | Tip Size | Output in Fluid Ounces | Nozzle # | Tip Size | Output in Fluid Ounces |
| 1 | | | 11 | | |
| 2 | | | 12 | | |
| 3 | | | 13 | | |
| 4 | | | 14 | | |
| 5 | | | 15 | | |
| 6 | | | 16 | | |
| 7 | | | 17 | | |
| 8 | | | 18 | | |
| 9 | | | 19 | | |
| 10 | | | 20 | | |
| | Output | | | Output | |
| | | | | Total Output | |

(Looking at the sprayer from behind, #1 nozzle is on left side)

$$\text{Average output} = \frac{\text{Total Output in fluid ounces}}{\text{Total number of nozzles}} = \frac{\_\_\_\_\_\_\_\_\text{ fluid ounces}}{\text{nozzles}} = \_\_\_\_\_\_\_\_\_\text{fluid ounces (Average Output)}$$

Minimum Output = 0.95 X ________ Average Output = ________ Fluid ounces

Maximum Output = 1.05 X ________ Average Output = ________ Fluid ounces

**Replace nozzles if output is greater than 10% variation between nozzles.**

Replace all nozzles if average output is 15% more than a new nozzle's output (from manufacturer's chart or discharge test).

The ounces collected per nozzle for the exact number of seconds equal the rate of spray per acre in gallons.

____________**GPA**

(Example: If 18 ounces are collected in the time noted in #2 above, you are spraying 18 gallons per acre from that nozzle).

**SWD in grapes: How much of a problem?**

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Since its arrival in New England in the summer of 2011, spotted wing drosophila (SWD) has caused extensive losses of small fruit crops. In order of their decreasing susceptibility to damage, these would appear to be ranked: raspberries, day-neutral strawberries, blueberries, cherries, and peaches. Where do wine grapes rank? Despite the claims of extraordinary damage to certain grape varieties in 2011 and 2013, my impression is that answering this question has a "Which came first, the chicken or the egg?" quality. Field observations of damaged, fruit fly-infested fruit appear to usually be associated with other damage or fruit rots occurring in these fruit clusters. However, it is possible that the SWD activity is leading to greater fruit rots (both sour rot and botrytis). Our climate and small farm size in the Northeast are more conducive to problems with SWD than along the Pacific Coast, but information is very limited for quantification of damage to wine grapes along the Atlantic states and Northeast.

Samples of grapes taken from the Valley Laboratory test vineyard, and enclosed to rear out flies, detected no *Drosophila suzukii* among the numerous drosophilids emerging from damaged fruit. Since these other species are unable to lay eggs into intact fruit, this observation suggests that the fruit fly development is secondary to fruit rots. Another possible scenario is that the SWD had already developed and exited from those clusters, leaving the other species to emerge later.

There are reports of SWD being the initial perpetrator in damaging thin-skinned wine grapes. Dark grapes are generally more susceptible to damage than light colored grapes. The susceptibility of grapes also increases dramatically as the brix level increases. During ripening fruit become softer, fruit rots increase, and feeding from other insects, such as yellow jackets, provide openings for SWD access to fruit.

Based on grower observations (http://swd.freeforums.net/thread/2/swd-forum), susceptible varieties include:
Cabernet Franc (highly susceptible)
Chancellor (highly susceptible)
Petit Verdot (highly susceptible)
Pinot Noir (highly susceptible)
Chambourcin
Chardonnay
Cabernet Franc
Gewurztraminer
Norton
Seyval Blanc
Maréchal Foch
Vignoles

Lower susceptibility varieties include:
Riesling
Merlot
Pinot Gris

Non-insecticidal management tools
It appears that the most important tools for SWD management in grapes are prevention of conditions that could lead to sour rot. Any aspect of growing grapes that leads to more open fruit clusters, air circulation around grape clusters, and thicker skins on the grapes will assist in preventing both sour rot and SWD outbreaks.

Growers comment that grape training systems can make a difference: using Vertical Shoot Positioning (VSP) rather than the Geneva Double Curtain (GDC) training systems may reduce the impact of SWD.

Prevention and control of sour rot (modified from http://www.agf.gov.bc.ca/cropprot/grapeipm/sourrot.htm)

- Reduce excessive vigour through the use of cover crops and/or the reduction of nitrogen fertilization and irrigation.
- Leaf removal between fruit set and veraison can lead to tougher berry skins.
- Apply gibberellic acid at 1-2 inch flower length to lengthen pedicels and reduce fruit crowding http://cestanislaus.ucanr.edu/files/111477.pdf
- Control wasps through trapping and nest removal.
- Control powdery mildew and botrytis to reduce grape berry lesions.
- Prevent bird damage.
- Bunch thinning is best done before or during veraison. Berries removed during late season thinning have higher sugars which can contribute to the fruit fly population increase.
- Discard affected bunches before or during harvest to minimize the negative effects on the wine.
- Some French sources recommend 2-3 applications of Bordeaux mixture (copper sulphate and hydrated lime) at ten to twelve day intervals around the time of veraison. Copper applied to the fruiting zone has the effect of thickening the grape berry skin, hence reducing the risk of lesions.

Insecticides for managing SWD in grapes
Prevention (through early reduction of the adult population) is more effective than playing "catch up" once larvae are protected within fruit. However, insecticides do not need to be applied to vineyards for SWD protection until there are some susceptible fruit, and varieties that are not susceptible do not need to be sprayed. Growers have most successfully maintained low populations of SWD when they rotate among classes of the most effective ingredients, which include zeta-cypermethrin (Mustang Max, 1 day PHI [pre-harvest interval]), spinosyns (Entrust or Delegate, 7 days PHI), and neonicotinoid insecticides, and apply products on a weekly schedule. If eggs are already present in fruit, only the neonicotinoids, which are systemic insecticides: imidacloprid (various names, 0 day PHI), acetamiprid (Assail, 7 day PHI), and

dinotefuran (Venom, 1 day PHI) have the potential to kill the developing larvae. Growers should make sure that there are no flowering plants that will be contacted by these sprays, as they can be toxic to bees.

Both the need and the effectiveness of spray programs should be informed by monitoring SWD populations, starting prior to veraison of the earliest ripening variety. Over the past two years, we have proceeded from having ineffective traps that were not competitive with surrounding ripe fruit, to having traps that are highly competitive with ripe fruit. The best attractant and traps are easily made. The trap is a 16 fl. oz. (470 ml) red cup with a tightly fitting lid, a single stripe of black electrical tape approximately one inch (2.5 cm) from the top rim, punctured with 40 one-eighth inch (3.2 mm) holes (use a punch tool to do this) and placed in the fruit crop or surrounding vegetation with a wire hanger. The attractant bait consists of 50 – 75 ml per trap of the following recipe: water (12 fl. oz. [350 ml]), whole wheat (1 cup [240 ml]), apple cider vinegar (1 Tbsp [15 ml]), active dry yeast (1 Tbsp) and a few drops of an agricultural surfactant. For those not wishing to make traps or baits, products from a company in Spain, BioIberica, are nearly as effective as the homemade trap and bait, are more selective in trapping SWD, the bait does not spoil, and should be available on the market soon.

In summary, SWD should not be (and is not, in most locations) a major pest of wine grapes. When cultural and chemical practices are undertaken to manage the grapes so that they are less susceptible to sour rots, then SWD problems should be greatly reduced. The need for insecticide sprays can be minimized by using effective monitoring tools and only spraying the susceptible varieties when the fruit have become sufficiently ripe to support SWD egg laying activity.

*Disclaimer: Use of trade names for pesticides does not constitute an endorsement for that product. Always read and follow pesticide label directions.*

**Jack Frost Nipping at Your Nodes:**
**Grapevine Cold Hardiness and Strategies to Handle Winter Cold**

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Grape production in the northeastern United States was long considered a risky endeavor, due in large part to issues with plant damage from cold events. Being perennial plants, grapevines must face all of the weather conditions that occur in their environment, and successful plantings will reflect a combination of: site selection; physiological plant characteristics; and grower management practices which prevent, minimize, or mitigate damage from cold temperatures.

Selecting the proper site is the first step to avoiding cold damage problems in the vineyard. Cold temperatures experienced in vineyards can be tempered to some degree. If there is sufficient elevation drop from the vineyard to allow cold air to drain away from the planting, removal of barriers such as tree lines can help improve airflow. On sites where the topography is not sufficient to drain away cold air or obstructions cannot be removed, frost fans may be used on the coldest nights (or when vines are most tender, such as after budbreak) to pull warmer air from above, but only if an inversion layer exists. Soil drainage is an important but less considered site component of grapevine hardiness. Vines that grow in saturated soils experience poor overall vigor, and therefore are more prone to cold damage. Improving soil drainage in a vineyard through tile drainage, berms, or swales can therefore reduce the vines' susceptibility to damage from cold.

Cultivar selection is critically important to ensure that a hardy enough grape is chosen for the site. Within the cultivar categories commonly planted in New England, e.g. *vinifera*; French-American hybrid; and cold hardy hybrid; differences appear in the relative hardiness of specific varieties. For example, *vinifera* are not generally considered hardy enough for all but the best sites in Northern New England, but growers have had varying success with Riesling and Pinot Noir in exceptional sites (that's not to say that those varieties perform as they do in more mild regions, however, and their use is not generally recommended). Most northern vineyards use hybrid varieties that contain genetic material from North American species that impart cold hardiness, as well as other characteristics including disease resistance, predominant growth habit, season of budbreak, and juice quality parameters. Many of the older French-American hybrids are less cold hardy than varieties bred in Minnesota and other upper Midwest states (referred to here as 'Minnesota hybrids'), although they may be considered with caution for warmer areas such as the Champlain and lower Connecticut Valleys. The Minnesota hybrids generally can be grown throughout northern New England, as far as midwinter cold hardiness is concerned. This does not mean, however, these cultivars, some of which break bud early in the season, can avoid spring frost damage on every site, nor that the growing season is sufficiently warm or long enough to adequately ripen the crop.

Cold damage occurs in grapevines when water within plant cells freezes and expands, thereby rupturing the cell wall or components within it. Grapevines have evolved a number of characteristics that help minimize damage from freezing temperatures. Woody tissues such as trunks and canes withstand cold temperatures when the plant exports cellular water into the intercellular spaces so that, when frozen, it does not rupture the cell walls in plant tissues. This migration of water from within the cells also increases solute concentrations within the cells, thereby lowering the freezing point within, a phenomenon known as supercooling. Gradual temperature shifts in late fall to winter promote maximum acclimation in grapevines, while gradual warming in the spring leads to good deacclimation conditions. Deacclimation is simply the reverse of the hardening process under which vines prepare for spring growth, and deacclimating vines are more susceptible to cold injury than fully dormant vines.

Grapes have a unique strategy to ensure growth of the vine even in the event of cold injury. The compound buds present on one-year canes contain three separate bud primordial which can each develop into a shoot the following season. The largest primary bud is generally the most fruitful, vigorous, and *least hardy* of the three buds. Ideally, a grower wants to produce a crop from these buds exclusively, since crop quantity, quality, and consistency will benefit. In the event of damage to the primary bud through cold or other injury, and in some varieties even without damage to the primary, the secondary or tertiary buds may emerge and produce growth for that season. Midwinter cold damage to buds can be visually assessed after warming canes for 24 hours and slicing through the buds to look for visual browning which indicates bud death.

Vines begin the acclimation process in late summer in response to a change in day length. This occurs around veraison, which is one component of the hardening off process. The goal of the vine during this period is to ripen fruit so that it may spread seeds and maintain the species, and then to store nutrient reserves with which to harden off tissues and supply the vine during budbreak and early growth in the following year. Cold hardiness acclimation is an active process in grapevines. Shoot lignification (hardening off), nutrient storage, and even leaf fall all require energy derived from photosynthesis to occur. Because fruit act as a sink for photosynthate produced by the vine, vines with fruit hanging late in the season (e.g. high acid *riparia* varieties, long season *vinifera*, or ice winegrapes) may experience greater winter damage than those which have had a few weeks or more before a killing frost to harden off without the stress associated with fruit ripening.

The best way to ensure optimum cold hardiness for a particular vineyard is to practice balanced viticulture. This refers to a theoretical, but achievable, state where fruit production and vine growth are balanced so that the quality of each is optimized. Several factors will affect this relationship. Vines should be well pruned, shoot thinned early, and canopies managed using best practices such as shoot thinning, cane positioning, and modest leaf removal. Well-ripened fruit, harvested at the optimum time, generally indicate that the vine is in good shape to go through a typical winter. Where fruit ripening is delayed or inconsistent throughout the canopy, vines are likely stressed and cold hardiness reduced. Nutritional balance is also critical in maintaining cold hardiness. Although research has shown limited effect from increasing nitrogen or potassium fertilization on cold hardiness, overall vine nutrition does affect the plant's ability to handle winter cold. Therefore, growers should have petioles and soils analyzed and maintain an adequate nutrition program to ensure good vineyard performance. In addition to sound viticultural management, vineyards that receive adequate pest management programs in the prior season will be more cold hardy than those that experience damage and defoliation from disease and insect pests. If these all sound like the same recommendations typically given for best managing your vineyard during the growing season, they are- healthy vines with a well-ripened crop of fruit and wood will withstand cold temperatures better than poorly managed or overcropped vines, because the vine can maximize photosynthate production and partition sugars and starches into stored tissues.

The deacclimation process is especially important for minimizing spring frost damage in vines. Gradual warming, with no significant dips into sub-freezing territory after the vines have begun to prepare for spring growth, helps to minimize damage to tender buds and shoots. Cultivars deacclimate differently to one another, which can lead to variable hardiness in the vineyard at certain times of the year. For example, Marquette, which is one of the cold hardy Minnesota hybrids, deacclimates before *vinifera* vines such as Riesling, and thus, for a few critical weeks in the spring, it is the less hardy of the two. Methods for delaying budbreak or managing temperatures after deacclimation has occurred are limited. Planting cultivars with early budbreak on north-facing sites may delay deacclimation, while planting those same cultivars higher on a slope may avoid the coldest temperatures experienced on a site when they have resumed growth in the spring. Delaying pruning until after expected spring frosts have passed, or ‘double pruning’, i.e. pruning to long spurs and following with adjustment of final bud count after frosts are no longer expected, can delay budbreak to some degree. Also, application of soybean oil to dormant vines in spring can delay budbreak by two days to around two weeks, but this strategy is recommended only for experimentation by growers until its performance can be fully tested. Vine training systems can also help minimize damage from spring frosts. During radiation frost events, the coldest air is located near the ground surface, so elevating the region where productive buds reside (i.e. high wire cordon systems) can help minimize cold damage after budbreak. However, this system should only be used on varieties that are fully hardy to expected midwinter lows, since the fruiting zone of the vine is held above any insulating snow cover or other material.

The use of snow cover (if it can be relied on) or other insulating materials is common in many vineyards, particularly on grafted vines, where the scion cultivar must be protected in the event that trunks are damaged. By protecting above the graft with snow, mulch, or mounded soil, the temperatures experienced can be 25°F or more above ambient temperature. Training systems such as Guyot (low-wire cordon), low head (fan), and ‘J-style’ allow for growers to cover vines with soil or mulch in fall to protect fruiting buds. These systems however are very labor intensive, require careful canopy management, and may produce poor-quality fruit due to problems with light interception on fruit located low in the canopy. For those reasons, it is recommended to select varieties that are hardy to expected midwinter in the vineyard, rather than to adapt and apply management strategies to protect tender vines.

Recommended resource: Winter Injury to Grapevines and Methods of Protection. Zabadal, T. (ed.) http://www.emdc.msue.msu.edu/product/winter-injury-to-grapevines-and-methods-of-protection-685.cfm