2018

MID-ATLANTIC
fruit & vegetable convention

PROCEEDINGS

for the vegetable, potato, greenhouse, small fruit & general sessions

SPRAY INNOVATIONS

SWIHART Sales Company
– Mist Sprayers –

We offer a complete line of low volume

Mist Blowers

Excellent for spraying CHRISTMAS TREES, vegetables, produce, orchards, vineyards, pecan trees, livestock, nurseries, mosquitos, chicken houses, etc.

Motor Models available

Agrimist INNOVATIONS

Low Maintenance High Performance

FREE Shipping

References available in your area

For free brochure contact:

Swihart Sales Company

7240 County Road AA, Quinter, KS 67752

785-754-3513 or

800-864-4595

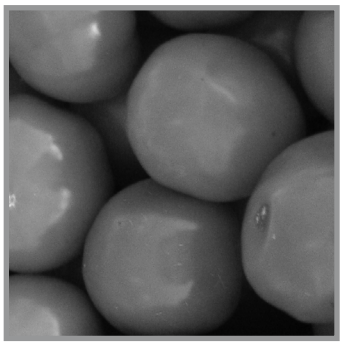
www.swihart-sales.com

2018 Mid-Atlantic Fruit and Vegetable Convention

Proceedings

FOR THE

VEGETABLE, POTATO, GREENHOUSE, SMALL FRUIT AND GENERAL SESSIONS



January 30 to February 1, 2018

Hershey Lodge and Convention Center

Hershey, Pennsylvania

sponsored by

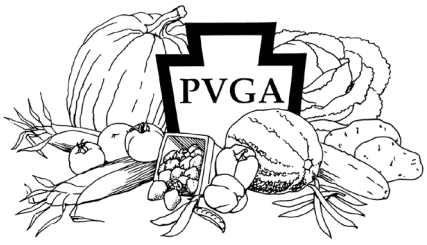
the State Horticultural Association of Pennsylvania
the Pennsylvania Vegetable Growers Association
the Maryland State Horticultural Society
the New Jersey State Horticultural Society and
the Virginia State Horticultural Society

in cooperation with

Penn State Extension
Rutgers Cooperative Extension
the University of Maryland Extension and
Virginia Cooperative Extension

Proceedings published by the

Pennsylvania Vegetable Growers Association
815 Middle Road, Richfield, Pennsylvania 17086-9205
717-694-3596 www.pvga.org



Pennsylvania Vegetable Growers Association

An association of commercial vegetable, potato and berry growers

Board of Directors

President: David Miller '20
First Vice President: Jonathan Strite '19
Second Vice President: Brian Campbell '18
Secretary-Treasurer: William Reynolds '19
Past President: Robert Shenot '19
Members: Christopher Harner '20
Barron Hetherington '19
Alan Kemmerer '19
David King '19
Kenneth Martin '20
Eric Oesterling '18
Michael Orzolek '18
Christopher Powell '20
Rita Resick '20
John Shenk '20
Jeffrey Stoltzfus '20
Thomas Strzelecki '18
Randy Treichler '18
Mark Troyer '18
Timothy Weiser '19

Staff

Executive Secretary: William Troxell, Troxell Administrative Services

Educational Committee

Jonathan Strite – chair, Steven Bogash, Jennifer Glenister, Beth Gugino, Arthur King, David King, Lois Klinger, David Miller, Eric Oesterling, Robert Pollock, Jeff Stoltzfus

Convention Task Force

General Chair – Jonathan Strite
Program Chairs – Pumpkins/Vine Crops – Thomas Butzler and Timothy Elkner
Organic Vegetable Production – Elsa Sanchez General Vegetables – Michael Orzolek and David King
Potatoes – William Lamont Ethnic/Specialty Vegetables – John Esslinger
Root Vegetables – Beth Gugino, Lee Stivers and Dave King
Tomatoes and Application of Drones – Kenneth Martin
Kale/Brussels Sprouts, Asparagus – Steven Bogash
High Tunnels – Steven Bogash and Arthur King
Sweet Corn – Shelby Fleischer Rhubarb – Thomas Butzler
Greenhouse Ornamentals – Sinclair Adam and Steven Bogash
Cover Crops and Soil Health/Reduced Tillage – Beth Gugino and Megan Chawner
Small Fruit – Kathleen Demchak Food Trends – Heather Manzo
Cut Flowers and Micro Greens – Thomas Ford Farm Management – John Berry
Farm Market Development – Brian Moyer Third Party GAP Audits – Jeffrey Stoltzfus
Wholesale Marketing – Lela Reichart and Laura England
Agritainment – Thomas Butzler and William Reynolds Marketing on Social Media – Shannon Dill
Educating Consumers and Media to Your Advantage – William Hlubik
Alternative Activities for On-Farm Marketing – Michelle Casella
Other Members – David Adams, Tanner Delvalle, Diane Erb, Gary Faulkner, Peter Ferretti, Jennifer Glenister, Kaitlin Horst, Lois Klinger, Nolan Masser, Benjamin Moyer, David Miller, Eric Oesterling, Robert Pollock, Steve Sample, Thomas Strzelecki, Randy Treichler, Grant Troup, Adam Voll

Audio-Visual Coordinators: Thomas Butzler, Robert Pollock, Don Seifrit, Brian Lehman and Becky Wiepz

TABLE OF CONTENTS

TOMATOES

ORGANIC VEGETABLE PRODUCTION

RHUBARB

KALE/BRUSSELS SPROUTS

CUT FLOWERS

ROOT VEGETABLES

ETHNIC/SPECIALITY VEGETABLES

PUMPKINS/VINE CROPS

GREENHOUSE ORNAMENTALS

GENERAL VEGETABLES

TABLE OF CONTENTS

GENERAL VEGETABLES continued

SOIL HEALTH/REDUCED TILLAGE

SMALL FRUIT

HIGH TUNNELS

SWEET CORN

POTATOES

ASPARAGUS

APPLICATION OF DRONES AND MAPPING – WHERE IS THIS GOING?

FARM MANAGEMENT

THIRD PARTY GAP AUDITS

FOOD TRENDS

AGRITOURISM

FARM MARKET DEVELOPMENT

EDUCATING CONSUMERS AND MEDIA TO YOUR ADVANTAGE

ALTERNATIVE ACTIVITIES FOR ON-FARM MARKETING

MARKETING ON SOCIAL MEDIA

GROWING GOOD NEIGHBORS THROUGH STEWARDSHIP & COMMUNICATION

Stephanie Regagnon
FieldWatch, PO Box 221610, St. Louis, MO 63122

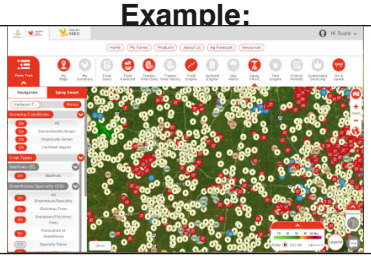
FieldWatch, Inc® is a non-profit company that promotes communication between producers of specialty crops, beekeepers and pesticide applicators in support of ongoing stewardship activities. DriftWatch™ and BeeCheck™ are programs of FieldWatch and are free, voluntary mapping tools used to promote awareness and collaboration on the ground.

These platforms feature an easy-to-use Google Maps™ interface that clearly shows pesticide applicators the locations of registered areas so they can utilize the data as they plan and prepare for their applications. FieldWatch data can be viewed and live-streamed through other software platforms so that applicators can easily see FieldWatch crop sites and beehives through other platforms they may be using.

Why FieldWatch?

- Increased Stewardship
  - Increased Communication
  - Data / Knowledge
  - Free to Use – Easy to Access – Voluntary
  - Our Industry relies on Relationships with and Respect for our Neighbors
  - Freedom to Operate

Our collaboration tool was originally designed by the Purdue University Agricultural and Biological Engineering Department with input and support from Purdue University Cooperative Extension. It is now operated by FieldWatch, Inc, a non-profit company created in collaboration with interested agricultural stakeholder groups who represent the entire agriculture value chain. FieldWatch is currently operating in fourteen states and one Canadian province and is expanding rapidly throughout the United States. In early 2018, FieldWatch will be adding a minimum of three new states.

Field Signs:	Technology Partner Example:	FieldWatch Contact Box:
		

During this presentation you will learn more about how to use our tool, how to expand our platform into your area and what new innovations are coming this year. For more information, please visit our website: www.fieldwatch.com.

Stephanie Regagnon is the President & CEO of FieldWatch, Inc., a non-profit company promoting stewardship and collaboration in agriculture. She has dedicated her career to the agriculture and renewable energy industries in Washington, DC, and St. Louis, MO for close to 20 years. She was recognized for her work in community outreach by the St. Louis Business Journal as a "40 Under 40" leader and by Ameren Corp as a "Community Light". Stephanie currently serves on the board of the non-profit she founded, Ava's Grace Scholarship Foundation, as well as chair of the Young Friends Committee of the Danforth Plant Science Center. Stephanie resides in St. Louis with her family.

BACTERIAL DISEASES OF TOMATO: DISCUSSION OF BEST MANAGEMENT PRACTICES

Beth K. Gugino
Department of Plant Pathology and Environmental Microbiology,
The Pennsylvania State University
219 Buckhout Lab, University Park, PA 16802
bkgugino@psu.edu

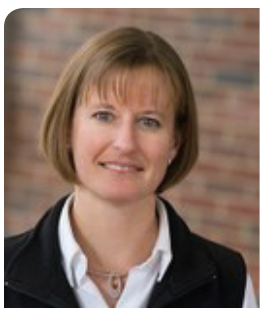
Bacterial diseases of tomato continue to be problematic across the mid-Atlantic region. Not only can these diseases directly damage the fruit, severe foliar disease can lead to defoliation further reducing both the quality and quantity of marketable fruit. The bacterial diseases of concern in this region include bacterial spot (caused by several species of *Xanthomonas*), bacterial speck (caused by *Pseudomonas syringae* pv. *tomato*) and bacterial canker (caused by *Clavibacter michiganensis* subsp. *michiganensis*).

All three diseases are favored by wet conditions especially the wind-driven rains that accompany thunderstorms which easily spread the bacteria locally within the field. Bacterial spot and bacterial canker are favored by warmer temperatures than bacterial speck; 75 to 90°F compared to 63 to 75°F, respectively.

Foliar lesions of bacterial spot and speck are initially small, dark brown or black and circular and may be surrounded by a yellow halo. As the lesions expand, they coalesce and portions of the leaf or the entire leaf will turn yellow and die. Lesions on the pedicals can cause flower abortion. Lesions will develop on immature fruit as a result of infection of the fruit hairs. The fruit lesions are initially small and dark brown. As the fruit ages, the bacterial spot lesions will increase in diameter and have a scabby or corky appearance while bacterial speck lesions will remain small and appear more superficial on the surface of the fruit. Bacterial canker causes a marginal necrosis around the edges of the leaves rather than distinct leaf spots and the lesions on the fruit are small with a dark brown center surrounded by a white halo. Bacterial canker can also move systemically throughout the plant in the vascular tissue which leads to vascular discoloration within the stems.

Young bacterial spot foliar lesions can be difficult to distinguish from those of early blight or Septoria leaf spot however as the lesions expand, early blight lesions will develop concentric rings while lesions from Septoria will become tan in the center will small black dots called pycnidia. Early blight fruit lesions will develop similar concentric rings as on the leaves while Septoria will not cause fruit symptoms.

The primary sources of bacterial inoculum are infected seed, infected crop debris and contaminated equipment (tools, greenhouse structures, stakes, etc.). The bacteria are splash dispersed through overhead irrigation, during wind-driven rain events and handling of wet plants especially when training. When managing bacterial diseases, it is important to keep in mind that bacteria readily multiply and spread under warm wet conditions; much faster than fungal pathogens. Once the bacteria land on a plant they then need a natural opening or wound to infect unlike



Beth K. Gugino is an Associate Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University located at University Park, PA. Her extension and research program focuses on the identification, epidemiology and management of vegetable diseases important to the Pennsylvania and the Northeast region. She received her B.S. in Horticulture and M.S. and Ph.D. in Plant Pathology from The Pennsylvania State University. She was a post-doc at the New York State Agricultural Experiment Station with Cornell University working with diseases of vegetable crops and soil health for four years before returning to Penn State in June 2008.

a fungal pathogen that can directly penetrate the plant tissue. Therefore, in order for protectant bactericides to be effective, they must be applied and come in contact with the bacterial cells prior to them entering the plant. This is in contrast to some fungicides that can stop the fungal infection process even after the pathogen has initially entered the plant. Unfortunately, our ability to detect bacterial pathogens associated with the seed and/or transplants is not below the threshold to cause disease so an integrated approach that focuses on excluding bacteria from production system is critical for successful bacterial disease management…always assume that you will have bacterial disease issues. Since it is primarily the immature fruit that are more susceptible, minimizing potential spread from the seed through the main fruit set will minimize potential harvest losses.

Also plant stress whether due to environment or resulting from soil compaction, weed and pest pressure and field operations can also play a large role in plant susceptibility to bacterial pathogens. Implementing strategies to optimize planting and growing conditions can help also help reduce losses.

Bacterial disease management strategies:

- **Select pathogen-free seed from a reputable source**. Although often easier said than done, it is important to purchase the highest quality seed possible. The seed extraction process will not reliably eliminate bacteria from the seed so treating the seed either with a chlorine bleach (1:5 dilution for 1 minute) to disinfest the seed surface, hydrochloric acid (5% HCl for 6 hours), hot-water seed treatment (122°F for 25 min) to disinfest the seed surface as well as eliminate bacteria that may be under the seed coat may be necessary. In order to not reduce seed germination and viability it is important to follow established seed treatment protocols. With funding from the Pennsylvania Vegetable Marketing and Research Program/Pennsylvania Vegetable Growers Association and the Northeast IPM Program, four sets of hot-water seed treatment equipment have been purchased and are available for use by growers in Pennsylvania (check with your local extension educator about availability).
- **Sanitation during transplant production**. Sanitation is an essential component to transplant production. Whether you are growing your own transplants or purchasing from a supplier, sanitation practices need to be in place to reduce potential losses to bacterial diseases. Some of these practices include:
  - Removing all plant material including weeds from the greenhouse between crops.
  - Using sterile potting mix and new trays, if possible. If re-using trays, sanitizing them with a disinfestant once all the organic matter has been removed. Keep in mind that disinfestant products will be neutralized and become ineffective in the presence of organic matter.
  - Disinfest tools and equipment and greenhouse surfaces before the growing season. Wood can harbor bacterial pathogens between seasons so minimizing the use of wood in the greenhouse is important.
  - Avoid co-mingling seed lots (as well as tomatoes and peppers) both during seeding and within the greenhouse to minimize potential cross-contamination.
  - Minimize handling of the plants and movement within the greenhouse as much as possible.
  - If symptoms are observed, remove the entire flat and adjacent flats to prevent further spread. Many of the seedlings may be infected but are not yet showing symptoms and may not develop symptoms until planted in the field.
- During transplant production **minimize leaf wetness** through timing of watering, managing relative humidity and ventilation. Either bottom watering or using low pressure nozzles for watering will minimize potential damage to the plant and ports of entry for the bacterial. Also do not handle plants when they are wet or allow them to drop on each other when preparing for shipping.
- In the field, follow a minimum **three year crop rotation** out of solanaceous crops including pepper. The bacterial spot pathogen cannot survive in the soil in the absence of crop residue. Also manage any solanaceous weeds or volunteer that can harbor bacterial pathogens between seasons.

- **Minimize crop stress** by promoting good soil drainage, adequate crop fertility and maximizing air circulation. Utilize drip irrigation whenever possible.
- Separate seed lots when possible to minimize potential spread if one seed lot is infested. **Separate sequential plantings** and **work in the youngest planting first**. Once the main fruit crop is set, late-season foliar symptoms and potential spread to the fruit are less problematic. Plowing down crop residue soon after harvest is complete will facilitate the decomposition of crop residue and reduce spread to younger successive plantings.
- Make it a practice to **purchase new wooden planting stakes each season**. Bacteria can survive in the cracks and crevices overwinter. If necessary, power-washed stakes can be sanitized by soaking in a number of sanitizing products such as Oxidate, Greenshield, Zerotol, etc. Heat treating the stakes either in a kiln or by steam may be another treatment option.
- The **application of in-season products** for managing tomato bacterial diseases is not a silver bullet. In regions of the country, copper-resistant/tolerant bacterial populations have reduced the efficacy of using copper-based products to reduce plant-to-plant bacterial spread by killing bacteria on the surface of the plant through direct contact. Nevertheless, fixed copper-based fungicides are still recommended and should be tank mixed with mancozeb early in the season. A number of research-based trials have demonstrated that when applied starting early, products that boost the plants defense system such as Actigard 50WG (a.i. acibenzolar-S-methyl) can help reduce bacterial disease (primarily bacterial spot and speck) incidence and severity in some fields. This product works to triggers the plant's own defense system to produce proteins and other products that enable the plant to suppress pathogens. Typically, these defense mechanisms are only triggered when a plant detects a pathogen. Priming or the pre-activation of the plants defenses enhances the plants defense response.
- In the greenhouse, **bacteriophage** (viruses that infect bacteria) may help to reduce bacterial populations on the plant surface. These viruses are very specific to the bacterial species and when they come in contact, the virus injects its RNA into the bacterial cell where it replicates and causes the bacterial cell to lysis or break open. Streptomycin-based products can also be used during transplant production to manage bacterial populations on the surface of the transplants.

In order to be effective, an integrated approach to the management of tomato bacterial diseases needs to be employed from seed selection through fruit production. Although a challenge to manage, understanding the biology and epidemiology of these diseases can help identify strategies to reduce losses in the field and can help explain why management efforts may have failed in the past.

MAGNESIUM BASED NANOMATERIALS FOR MANAGEMENT OF BACTERIAL SPOT OF TOMATO

Ying-Yu Liao, Department of Plant Pathology
University of Florida, Gainesville, FL, USA

Tomatoes are an economically valuable crop in the United States. In 2015, 37,313.34 hectares of fresh market tomatoes were harvested in the U.S with a harvest of 1.2 million metric tons, valued at 1.2 billion dollars (USDA, 2017). Florida, which is the largest fresh market producer in the U.S., accounted for 36% of the annual tomato production value. Bacterial spot of tomato, caused by four Xanthomonas species (i.e. *Xanthomonas euvesicatoria, X. gardneri, X. perforans, and X. vesicatoria*), is difficult to manage in Florida due to environmental conditions that favor the disease throughout the year. Although bacterial spot disease is a major bacterial disease in fresh market tomato production, leading up to 50% yield losses and reduced fruit quality, there are only a few treatment options available for effective disease management.

Why it is important to find novel disease management strategy?

1. The EPA has posted EPA's draft human health and ecological risk assessments in 2017, and has suggested that copper bactericides be reduced on several crops based on ecological risks for non-target organisms exposed to field runoff containing Cu.
2. The heavy use of Cu-based bactericides might lead to metal accumulation in the soil.
3. Cu-based bactericides are still frequently used by growers, given the limited availability of effective disease management options.

Considering the negative aspects of Cu use and accumulation, identifying sustainable and effective alternative management strategies is critical.

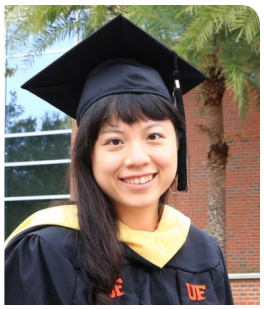
What are the currently available treatment options?

Other currently available treatment options have significant limitations as well

1. Commercial plant defense activators can reduce yield and the efficacy of bacteriophages is adversely affected by low humidity, UV light and high temperature.
2. Florida tomato growers continue to use a combination of Cu-based bactericides, plant defense activators, bio-fungicides, and cultural practices, including use of healthy seeds and transplants.

Thus there is an immediate need for development of materials with high efficacy against Cu-tolerant strains of *X. perforans* in Florida.

Ying-Yu Liao is currently a first year doctoral student in Plant Pathology at the University of Florida. Research projects are focused on 1) evaluating novel management strategies 2) the role of Type VI secretion system of bacterial spot of tomato, *Xanthomonas* spp. She has her B.S. degree in Agricultural Chemistry from National Taiwan University and her M.S. in Plant Pathology from University of Florida.



Magnesium Based Nanomaterials for Management

Our recent research discovers novel antibacterial properties of Mg-based nano-materials against *X. perforans*.
A non-formulated magnesium oxide nanoparticle (Nano-MgO)

1. Nano-MgO at 100 µg/mL completely inhibited growth of a Cu-tolerant strain of *X. perforans*, while 1000 µg/mL of commercial grower bactericide formulation Kocide 3000 had no significant effect.
2. In greenhouse and field experiments, disease severity was significantly reduced by Nano-MgO at 200 µg/mL compared untreated controls (UT) whereas grower's standard, copper-mancozeb was not significantly different compared to UT ($p = 0.05$).
3. Elemental analysis of fruit samples showed that Nano-MgO treatments did not differ- entially accumulate Mg, Cu, Ca, K, Mn, P and S compared to untreated controls.

Formulated Mg-based nanomaterials

1. In our current work, formulated Mg-based nanomaterials significantly reduced disease severity to as low as 100 µg/mL compared with copper-mancozeb and UT ($p = 0.05$) in two greenhouses.

This study demonstrated for the first time the antibacterial potential of Mg-based nano-materials against *X. perforans*. Based on the preliminary findings, we hypothesize that Mg-based nano-material will be an effective alternative to the current grower standard.

GETTING MICRONUTRIENTS IN THE ZONE FOR THE BEST TOMATOES

Steve Bogash, Technical Sales Manager, Marrone BioInnovations, Inc.

January 30, 2018

One of the great misconceptions among growers is in the understanding of the importance of micronutrients in creating a great tomato harvest. While the required amounts of these nutrients are very low in comparison to the levels of macronutrients, their importance is still very high. Typically major nutrients or macronutrients can be measured expressed as a percentage of dry matter in plant tissue while the much smaller micronutrient levels are expressed as PPM (parts per million). These smaller amounts lead many to believe that they are less important. However, plant health and fruit quality suffers greatly when there are insufficient amounts of these micronutrients as they are important in cell division, development of flavor compounds, cell wall formation, fruit set and other plant biochemical processes. Fruit and plant health also suffers when micronutrients are out of balance with each other or in excess,

Major nutrients include Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), and Potassium (K). Of these, C, H, & O are classed as structural elements, and are extracted by plants from the air and water and make up about 90% of plant tissue. N, P, and K are commonly considered as the macronutrients, make up much of the remaining plant tissue and are the 3 numbers expressed as percentages on fertilizer bags. Required in lesser amounts as critical micronutrients by plants are Calcium (Ca) and Magnesium (Mg) followed by Sulfur(S), Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), and Zinc (Zn). Of great interest in our industry at this time as well as receiving a lot of research are the elements Silicon (Si), Sodium (Na), Vanadium (V) and Nickel (Ni). So far these last four elements are not considered critical nutrients, but research indicates that they may be beneficial in the right circumstances.

We will consider the list of currently considered "critical" micronutrients for our region. Mo, Mn, and Cl have been left out of this section as they are seldom a problem. All of the tissue levels are based on samples of whole leaves collected as "Most Recently Mature." On a typical tomato plant, this is the fourth or fifth whole leaf down from the growing point. This leaf will be fully expanded and no longer yellow in appearance.

Calcium (Ca): Calcium is critical in cell wall formation. Plant Ca deficiencies include Blossom End Rot (BER) along with many variations of skin cracking. Calcium deficiencies are typically part of a series of problems including uneven watering, low pH, moisture stresses, and imbalances with the nutrients K, Mg and N. Ca tomato tissue levels at fruiting should be near 3%. Calcium Nitrate and Calcium chelates are typically applied through irrigation or foliarly to increase available calcium. Irrigation must be managed properly to solve a Ca deficiency. High levels of calcium (above 4%) can suppress plant uptake of Mg and K. This is the typical 'too much of a good thing.'

Magnesium (Mg): The comments for Mg are very similar to Ca as these elements must be in balance with each other. Like Ca, severe Mg deficiency can cause BER. Mg tomato tissue levels at fruiting should be near .9%. Field observations indicate that a ratio of 3/4 parts Ca to 1 part Mg assuming that both are near the peak of sufficiency produces excellent fruit with strong skins and minimal cracking. Magnesium sulfate, Sul-Po-Mag, EDTA chelated Mg, and Magnesium Oxides are common sources of additional Mg. EDTA and Amino acid chelates of Mg are especially good at rapid corrections in low Mg levels. As with Ca, too much Mg can suppress Ca and K levels. Preplant applications of Epsom salts ($MgSO_4$) are a good way to get your soil in shape prior to planting.

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve now works with the product development team at Marrone Bio Innovations, Inc to create, field test, and market new biological plant pest management products. He has continued to do applied research in field and high tunnels on bell peppers, tomatoes, cucumbers and processing tomatoes seeking to improve yields and quality. Proactive pest management using biological control agents is an important factor in all of these trials.
Steve has been doing extensive trials in high tunnel and field tomatoes, bell peppers, and cucumbers with a focus on plant nutrition and biological pest management since 2000. Evaluating more than 500 varieties of tomatoes for flavor, appearance, disease resistance and general usability has made Steve very opinionated when it comes to tomato varieties.

Sulfur (S): Sulfur is especially important in the creation of the complex of organic compounds that make up the odor and flavor profiles of vegetable fruit. Tissue sulfur levels at fruiting should be between .8 and 1.2%. Potassium sulfate, Sul-Po-Mag, Magnesium sulfate and Ammonium sulfate are all common sources of sulfur. Since these are common materials used in blending fertilizers, S is seldom a limiting nutrient.

Boron (B): Boron is extremely important to growers in our region as this element is often deficient in our soils. B deficiency is often expressed as poor development or death of the growing point since it is very important in many cellular division processes. Borax and Solubor are often applied foliarly at #1/2 -1 / Acre annually. B tissue levels should be between 50 and 75ppm. Bringing B tissue levels to 75 ppm can increase fruit quality by reducing cracking and uneven ripening. Many fertilizer suppliers have caught Boron fever and have added it their blends. The down-side of this is that we now often see B toxicity as levels over 150ppm are not unusual. Growers need to be careful of overapplying B.

Copper (Cu): Although copper deficiency is seldom seen in the field, observations indicate that keeping Cu levels near 20ppm will enhance plant growth and aid in the plants ability to resist diseases. Most copper bactericides / fungicides supply sufficient amounts of Cu when used in rotation as part of an overall disease management program.

Iron (Fe): Iron is very important in the plants ability to utilize N and S. Many plant biochemical processes require small amounts of Fe. Recommended tissue levels are 100-300ppm. Iron deficient plants have interveinal chlorosis and yellowing of younger leaves. High pH soils or irrigation water can cause Fe deficiency. Iron chelate and Ferrous sulfate are good sources of additional Fe. Tomatoes benefit greatly from the management of irrigation water to a pH of 6.2-6.5. This increases Fe and K availability.

Zinc (Zn): Zn deficiency can appear as poor growth and/or poor fruit set and often appear very similar to Fe deficiency. The only way to identify this problem is by tissue testing. Zn levels should be between 20 and 50ppm. Zinc chelates, sulfate and oxides are common sources of additional Zn.

The best method to avoid micronutrient deficiencies as well as produce the largest crop with the greatest packout is to regularly soil and tissue test plants at critical points. Always test a tomato field prior to planting and apply nutrients as recommended. Then submit plant tissue for analysis at first blossom, 6-8mm green fruit, first fruit color (pink) and again at first harvest if you are planning on keeping the plants fruiting. If you need information on collecting proper plant tissue for analysis, please contact the author or your favorite tissue testing laboratory.

The excitement over sap testing seems to come and go. At this time, this technology appears to be useless for seasonal vegetable growers as it can take 10 days or more to get results back as the samples need to be send to Holland for processing. In addition, the recommended values have yet to withstand the kind of review that tissue testing has gone through and these tests are 2-3 times the cost. Regular plant tissue testing when done properly nearly always provides the level of information that we need to grow the best tomatoes.

IMPACTS OF CONVENTIONAL PEST MANAGEMENT PRACTICES IN ORGANIC FARMING

Galen P. Dively
Department of Entomology, University of Maryland, College Park, MD 20740
galen@umd.edu

Organic farms in intensively managed agricultural landscapes are usually next to or surrounded by conventional agriculture. To prevent contact with a prohibited substance applied on adjoining farms, organic certification requires defined boundaries and buffer zones, which can be as narrow as a tree line or hedgerow 25 feet wide. Although such buffers may prevent the movement of soil and pesticide drift, insect pest populations move about the landscape in a much larger spatial scale; thus, pest management practices used in conventional farming can influence pest populations and control measures applied on organic farms. Presented here are case examples of how conventional pest management practices have both positive and negative impacts on organic farming.

Regional suppression of pests. Bt corn hybrids containing the bacterium *Bacillus thuringiensis* (Bt) genes are now planted in 70 to 90% of the corn acreage in the mid-Atlantic region. Expressed insecticidal proteins in the plant tissue provide 100% control of the European corn borer (ECB). Because corn is the major reproductive host plant of this insect, areawide adoption of Bt corn has significantly reduced population recruitment of corn borer moths that migrate to and lay eggs in other host crops. Bt corn provides only partial suppression of the corn earworm (CEW), which is more tolerant to the expressed proteins. However, larval development is significantly delayed in Bt corn, so surviving earworms pupate later in the summer, are triggered into diapause and stay in the soil to overwinter; thus, fewer moths emerge to infest late season crops.

With data spanning four decades and across the mid-Atlantic region, trends in ECB and CEW activity, prior to (1976 – 1995; pre-Bt corn) and since Bt corn introduction (1996 – 2016), show significant regional population suppression of both pests, resulting in potential benefits to conventional and organic vegetable growers. Mean nightly captures of ECB and CEW moths declined significantly from means of 6.8 and 7.5 moths respectively during 1976-1995 to less than 2 moths per night during 1996-2016, a net decline of 72-75%. The decline in moth captures is significantly related to increasing percentage of Bt acreage planted. ECB damage in untreated sweet corn and peppers also declined as a function of Bt corn adoption. Using long-term data on ECB damage from insecticide efficacy trials, mean ECB damage in peppers in the mid-Atlantic region decreased significantly from 35% during 1980-1995 to 8% since Bt introduction in 1996, a 78% reduction. Similarly, mean sweet corn ear damage by ECB significantly declined from 50% during 1984-1995 to 15% since Bt corn introduction, a 70% reduction. Trends in control action based on blacklight trap counts of adult moths also showed a significant decline in the number of recommended insecticide sprays per crop cycle in each vegetable as a function of the percentage of Bt acreage planted. Furthermore, reported insecticide use in vegetable crops confirms the reduced usage over the past 25 years. In New Jersey, the total amount of insecticides applied in sweet corn and peppers declined by 79% and 85%, respectively. Taken altogether, the regional suppression effect of Bt corn adoption has had a positive impact on organic farmers by reducing ECB and CEW populations in their crops. Both pests have broad feeding and migratory behaviors as economically important pests on many crops, including field corn, sweet corn, popcorn, green bean, lima bean, cowpea, peppers, tomato, okra, potato, and soybean.

Galen Dively is a native of Blair County, Pennsylvania where he grew up on a dairy farm. He received his B.S. degree (1966) in biology at Juniata College and M.S. (1968) and Ph.D degrees (1974) in entomology from Rutgers University. As Professor and Extension Specialist in Entomology at the University of Maryland since 1972, he has developed many extension programs to assist growers and private consultants in the adoption of pest management practices. After retiring in 2006, he continues to work on research projects focusing on the risk assessment of pesticides on honey bee colony health; efficacy evaluation of new transgenic corn events; field evaluation of new insecticide formulations and active ingredients, with emphasis on organic products; and studies addressing information gaps in the biology and management of emerging pest species."

In addition to the regional effects of Bt corn, there are documented cases of more localized positive influences from conventional pest management practices on nearby organic farms. One case is the PRSV-resistant transgenic papaya that has been commercially grown in Hawaii since 1998 to control ringspot virus disease. Large-scale plantings of transgenic papaya provide a buffer zone to protect organic and nontransgenic papaya grown nearby. Virus-infested aphids feed on transgenic plants without causing the disease, which removes the virus from the aphids before dispersing to nontransgenic plantings. This has drastically reduced the amount of available virus inoculum and allowed growers to produce an economic crop of nontransgenic papaya. Similarly, organic farmers also could be benefiting by management practices used to control other crop diseases and possibly weeds on conventional farms. Arguably, overall weed pressure on commercial farms has been significantly suppressed by the herbicide tolerant crops, which have probably reduced the seed bank size of wind-dispersed weed species. In theory, this could reduce weed pressure on neighboring organic farms; however, there is no scientific evidence to document any positive impact.

Pollen contamination. As a potential negative impact, organic farmers have concerns about contamination of their crops, particularly sweet corn, due to the outcrossing of pollen from adjoining Bt corn fields. This route of genetic contamination depends on a number of factors, i.e. the distance between the Bt corn and organic crop, overlap in pollen shed, area of Bt corn around an organic farm, and the speed and direction of prevailing winds. It is important to note that corn pollen is one of the heaviest of the wind-pollinated plants, and pollen dispersal studies report that corn pollen deposition drops by 50 to 75% over distances of just 2 to 4 m from the field edge. A Greenpeace study in Germany found that Bt pollen contamination of organic corn declined to 2% and resulted in a contamination rate of 0.05-0.2% at 10 m. Pollen contamination is usually very low and easy to minimize by isolating organic crops both spatially and temporally from adjoining Bt corn. The organic farmer can plant sweet corn as an early crop to avoid high insect pressure later in the growing season or plant several weeks later than conventional farmers to avoid overlapping pollination periods; or not grow organic corn directly adjoining Bt corn. While these methods can limit the amount of pollen contamination, it is virtually impossible for organic farmers to grow an entirely pure crop. For this reason, the National Organic Program does allow a presence of GMO traits within organic crops as long as the organic farmer has met the required qualifications and regulations to reach certification. To date, there has never been an instance in which an organic farm has lost its certification because of cross-pollination with GMOs.

Pesticide drift. A more serious issue for organic farmers is the off-target contamination due to the airborne movement of pesticides from a conventional farm. Pesticide drift has always been a recurring problem, even for conventional farms. An organic farm next to a conventional farm should have a buffer zone in place to reduce the risk. Talk to your neighbors concerning spray applications and explain that you have sensitive crops and would appreciate it if they would spray when the prevailing winds are light or are moving away from your land. It should be noted that drift problems could increase now that conventional producers are experiencing Roundup-resistant weed problems and may be switching to the new 2,4-D and dicamba-resistant soybeans. Because these broadleaf weed herbicides do not harm grasses, they are also commonly used for lawn and turf management, and along roads, powerlines and railroads. Under certain weather conditions, these herbicides can vaporize days after application and drift off-site and cause damage to non-target crops. To date, there have been few documented incidences of herbicide drift on organic farms in the Mid-Atlantic region. More restricted use directions will be placed on these herbicides for 2018.

Insect resistance to Bt proteins. As mentioned above, transgenic Bt corn engineered with genes expressing insecticidal proteins are a major tool in insect pest management. With its widespread use, insect resistance is a major threat to the sustainability of the Bt technology. For all Bt corn types, the high dose requirement for resistance management is not achieved for corn earworm, which is more tolerant to the Bt proteins. In a long-term Maryland study, Bt expressing sweet corn hybrids were used as in-field screens to measure changes in field efficacy and Bt protein susceptibility to corn earworm. Results show significantly increased susceptibility and reduced control efficacy of Cry1Ab Bt sweet corn to corn earworms, since its commercial introduction in 1996, and significant reductions in field performance of Cry1A.105+Cry2Ab2 sweet corn, particularly during 2015-2017. Supportive data from laboratory bioassays confirm that surviving earworms collected from Bt sweet corn are now 54 times more tolerant

to the Cry proteins than a susceptible laboratory strain. Together, this rapid change in field efficacy in recent years and decreased susceptibility of corn earworm to Bt sweet corn provide strong evidence of field-evolved resistance in *H. zea* populations to multiple Cry toxins. Many conventional farmers either have stopped growing Bt hybrids or are applying more insecticide sprays to compensate for the reduced control efficacy. Additionally, since 2002, field-evolved resistance has been reported in fall armyworm for Cry1F protein in Bt corn, and bollworm (corn earworm) for Cry1Ac protein in Bt cotton.

The rise in insect resistance to the insecticidal Bt proteins has important implications for pest management in organic farming. There are 53 different Bt products listed on the OMRI website that are certified organic and may be used as a pesticide to control caterpillars and other insect pests. Many organic farmers use these insecticide sprays to control corn earworm and fall armyworm on several important vegetable crops, especially sweet corn, tomato, okra and cotton. Products such as DiPel, Javelin, Thuricide and others contain spores and active Cry 1 and Cry2 proteins that are biologically the same as those expressed in Bt corn. Thus, since they have the same mode of action, insect resistance to Cry proteins expressed in Bt corn and cotton has ultimately reduced the control efficacy of Bt insecticide sprays. Some organic farmers are experiencing this negative impact; however, Bt resistant populations of corn earworm and fall armyworm may be localized in the mid-Atlantic region to some extent and could change from year to year depending on the source of moths carried northward on weather fronts. Currently, this only affects control effectiveness of Bt sprays for corn earworm and fall armyworm; most products still work on cabbageworms, loopers, and other caterpillars.

Insect resistance to conventional insecticides. There are several examples of insect populations developing resistance to conventional insecticides that have negative impacts on organic insecticide use. Pyrethroid insecticides are commonly used in vegetable pest management to control insect pests. Because there are many inexpensive generic products, this class of insecticides has been used extensively to control corn earworm (also known as fruitworms on tomato, headworm on grain sorghum, pod worm on soybeans, and bollworm on cotton). Resistance monitoring has been conducted over the last 15 years to track the efficacy of pyrethroids against this insect. When first introduced, pyrethroids provided 95 to 98% control of corn earworm, but currently control efficacy has declined to around 50% due to resistance development. For conventional farmers, it is becoming increasingly necessary to shift to the more expensive and newer classes of insecticides. Pyrethroid insecticides are not certified organic; however, there are 23 pyrethrum products, such as Azera and PyGanic, on the OMRI list that are certified organic. These products are made naturally in contrast to the synthetic pyrethroids, but they use the same mode of action to kill insects. Thus, conventional use of pyrethroid insecticides has compromised the control efficacy of organic pyrethrum products, which affects many resistant insect pests in addition to the corn earworm.

Another example of how insect resistance development negatively impacts organic pest control involves the use of conventional insecticides that contain spinetoram (Radiant SC) or spinosad (Blackhawk, Consero, Conserve). These products have been commercially available for more than a decade, and both active ingredients have the same mode of action as 22 organically certified spinosad insecticides. One in particular is Entrust which is widely used in organic production. Unfortunately, conventional use of this insecticide class has led to resistance development in populations of several important insect pests (i.e.beet armyworm, onion thrips, western flower thrips). This means that products like Entrust are likely to have less control efficacy against these pests.

Emergence of new pests. Western bean cutworm is a new emerging pest that is increasing in population size and expanding its range from the Midwest eastward over the past decade. It has become a serious pest of sweet corn, legumes and dry beans in Ontario and parts of New York, detected in Pennsylvania with minor economic injury, but only first sightings elsewhere in the mid-Atlantic region. Most entomologists agree that the widespread adoption of Bt corn has led to this population shift. As an ear feeder, larvae are normally outcompeted in non-Bt ears by corn earworms which are highly aggressive and cannibalistic. In Bt ears, western bean cutworms are highly tolerant to the Bt proteins and able to survive due to the lack of competition with corn earworm. In effect, this shift in interspecific behavior has created a new pest problem for both conventional and organic farmers. If this pest reaches economic levels in the mid-Atlantic region, it will be very difficult to control with organic insecticides.

MANAGING WEEDS IN ORGANIC VEGETABLES

Alan Leslie Postdoctoral Research Associate
Department of Entomology, University of Maryland, 4112 Plant Science Bldg., College Park, MD 20742

Weeds are a persistent problem for organic vegetable production systems and represent a major portion of the cost of producing vegetable crops. Conventional vegetable farms benefit from available low-cost, synthetic herbicides to control a wide range of weeds on a large scale, while organic vegetable farmers typically can't rely on any single tool for complete weed suppression. Hand-weeding and cultivation/tillage are common methods for controlling weeds in lieu of synthetic herbicides, but they add significantly to production costs and frequent tillage can reduce soil quality. Organic vegetable farmers could benefit significantly from applying multiple low-cost strategies in combination to prevent weed problems. Integrated weed management (IWM) is the combination of chemical, cultural, genetic, biological, and mechanical practices in complementary ways to effectively reduce weed pressure. In this presentation, we will discuss a range of weed management strategies beyond cultivation and hand weeding that can be combined into an effective and profitable IWM plan that provides weed suppression while reducing costs and improving soil health.

When at all possible, steps should be taken to prevent weed problems from ever occurring on your vegetable farm. As a general rule, vegetable crops should not be planted in **fields with a history of weed problems**, especially perennial weeds. If farm size constraints do not allow avoiding these problem fields, then highly competitive vegetable crops should be prioritized over weakly competitive crops. Transporting seeds of problem weed species into new fields can be reduced by employing **good sanitation methods**. Regularly power-washing cultivation, mowing, and harvesting equipment between field operations will reduce the chances that weeds seeds will be introduced from one field to another. Also, buying seed that is certified weed-free, and thoroughly composting animal manures can prevent introduction of new and potentially invasive weed species to your farm. Finally, the decision to deploy weed control strategies often requires weeds to build up to a threshold level that will reduce crop yield. However some species of **highly invasive weeds** (such as Palmer amaranth) present such a great risk to future crops that they should be eradicated if even a single plant is present. This zero-tolerance policy towards certain species of problem weeds can prevent much more serious problems in the future.

Within vegetable plantings, further steps can be taken to maximize competitiveness of your vegetable crop over weed plants. One key strategy for reducing weed pressure is to maximize the amount of bare soil that is covered by your crop, which effectively shades out weeds. Increasing vegetable crop diversity through **intercropping** is one may to maximize the amount of ground that is covered by crop vegetation. This way, poorly competitive crops such as carrot and onion can be paired with species that grow rapidly and cover the ground quickly, such as snap beans or potato. **Plant spacing and arrangement** can also be manipulated to maximize the amount of ground that is covered by the crop plants, which maximizes vegetable crop competition over weeds while minimizing competition between vegetable plants. Promoting crop plant growth and vigor will also ensure the crop's competitive advantage over weed plants. Enhance **crop growth and vigor** by buying high quality seed with a high germination rate, selecting cultivars adapted to your local climate, and applying fertilizers and irrigation in ways that maximize crop uptake over weeds. Vegetable crops can also be given a direct competitive advantage over weeds by using transplants over direct-seeding whenever possible.

Dr. Alan Leslie is a postdoctoral research associate working with Dr. Cerruti Hooks in the Entomology Department at the University of Maryland. His research incorporates sustainable approaches to insect and weed pests in agronomic and vegetable crops. Current research includes using dead and living mulch from cover crops to suppress weeds in organic vegetables grown under reduced tillage. Alan got his Ph.D. from the University of Maryland studying invertebrate communities in agricultural drainage ditches on Maryland's Eastern Shore. He was born and raised in southern Maryland, and he and his wife Kiesha live near the UMD campus, in Glenn Dale

Crop rotation is one of the most effective tools for preventing weed problems in vegetable production. Continuously planting the same crop in the same field eventually allows certain weed species that are well adapted to that system to build up in the seedbank and become increasingly problematic. The goal of crop rotation is to change the cultural practices as much as possible between crops to ensure that no weed species can be well adapted to the changing habitat year after year. Good rotation schemes alter as many aspects as possible for alternating crop species. Examples include alternating: vegetation architecture, grasses and dicots, cool and warm season crops, and poor and high competitive ability. Rotations may also include alternating vegetables with agronomic crops, such as winter cereals or soybeans, which can form dense stands and provide good weed competition.

Tillage and cultivation together represent the principal weed removal strategy for many organic vegetable farmers. There are many such methods of mechanical weed removal, and new technologies are emerging that make use of optical sensors to help guide precision implements. Benefits of tillage include: good control of annual and perennial weeds, burial of weed seeds, loosening of compacted soils, increased nutrient mineralization, and warming of soils. However, frequent tillage reduces soil quality, can lead to a depletion of soil organic matter, can increase rates of erosion, and requires large inputs of fossil fuels. **Reduced tillage** techniques such as zone tillage and vertical tillage offer many of the benefits of tillage while preserving soil health and quality by reducing overall soil disturbance.

Organic vegetable farmers simply cannot rely on **herbicides** to provide season-long weed control. Examples of organic-approved herbicides include different formulations of vinegar (acetic acid), clove oil, and citrus extracts (d-limonene). These chemicals are non-selective, and cause damage to crop plants if they are exposed to sprays. Efficacy of these chemicals also tends to be restricted to small broadleaf weeds, with minimal control of grasses or larger broadleaf weeds. Furthermore, organic herbicides tend to be too expensive to apply at the required rates over large areas. With all of their limitations, there may be ways to incorporate organic herbicides into an IWM program. A few **bioherbicides**, which incorporate fungal and bacterial pathogens that can attack weeds, have been released in the U.S., but they tend to be too specific to a single or few species, and their efficacy is limited by environmental conditions. Development of future bioherbicides will be strongly driven by market factors, but organic agriculture is a likely target for new formulations.

Some alternative weed-removal techniques that can be applied to organic vegetable production include flame weeding and abrasive weeding. **Flaming** has the benefit of providing pre-emergence control of weeds by heat-killing weed seeds at the soil surface as well as post-emergence control of germinated weeds, especially of broadleaf weeds. Flaming may be a useful alternative to mechanical cultivation in shallow-rooted crops that may be damaged by soil disturbance. **Abrasive weeding** is a relatively new technique using different air-propelled grits to abrade and kill weeds. This technique has been shown to work especially well to control weeds emerging through the planting holes of plastic mulch, and can double as a method for delivering fertilizers to the crop plant. You can learn more about abrasive weeding from a webinar being hosted by eOrganic on March 29th. Visit the website https://learn.extension.org/events/3252 for details.

Mulch, especially **plastic mulch** is one of the most widely used weed control strategies in organic vegetable production. Plastic mulch can provide season-long weed control by physically blocking weeds from germinating within crops rows. Other benefits of plastic mulch include increased soil temperature, increased irrigation water use efficiency, improved vegetable quality, and some insect pest management. Disadvantages of plastic mulches include increased cost, labor associated with laying and removing plastic, disposal of used plastics, increased tillage requirements, and lack of effective inter-row weed suppression. **Organic mulch** from cover crop residue is an alternative to conventional plastic mulches that can provide weed suppression without the tillage required for plastic mulch. Fall-planted cereal cover crops such as barley or rye can be planted ahead of summer vegetable crops and terminated by flail mowing (Fig. 1B) or roller-crimping (Fig. 1C) once they have reached maximum biomass at anthesis. If the vegetable crop is planted into this residue without tillage or with minimum tillage, the resulting plant residue can form a physical barrier that effectively prevents weed seeds from germinating. Advantages of organic mulch from cover crops are that it requires fewer field operations and less tillage, and allows crops to better utilize rainwater.

Disadvantages of this system are that soils under no-tillage tend to remain cooler than bare soils (Fig. 1A), and may slow crop growth, and that organic mulch may not last the entire season if there is not adequate biomass.

Living mulches are an alternative to dead organic mulch that may extend weed suppression benefits throughout the season. Living mulches are a form on intercropping where the inter-crop space is planted with a non-crop plant that can effectively out-compete weeds, while not interfering with the cash crop's growth and productivity (Fig 1D). Ideal characteristics for a living mulch include rapid establishment, low stature, dense stand formation, and low maintenance. Examples of species effectively used as living mulches include buckwheat, various clover species, hairy vetch, and some grass species. Benefits of living mulches include season-long weed suppression, additional nitrogen input (for legume species), added habitat and resources for pollinators and natural enemies, and erosion control. Drawbacks of living mulches include additional maintenance in the form of mowing, and possible competition with the cash crop for light, water, or nutrients.

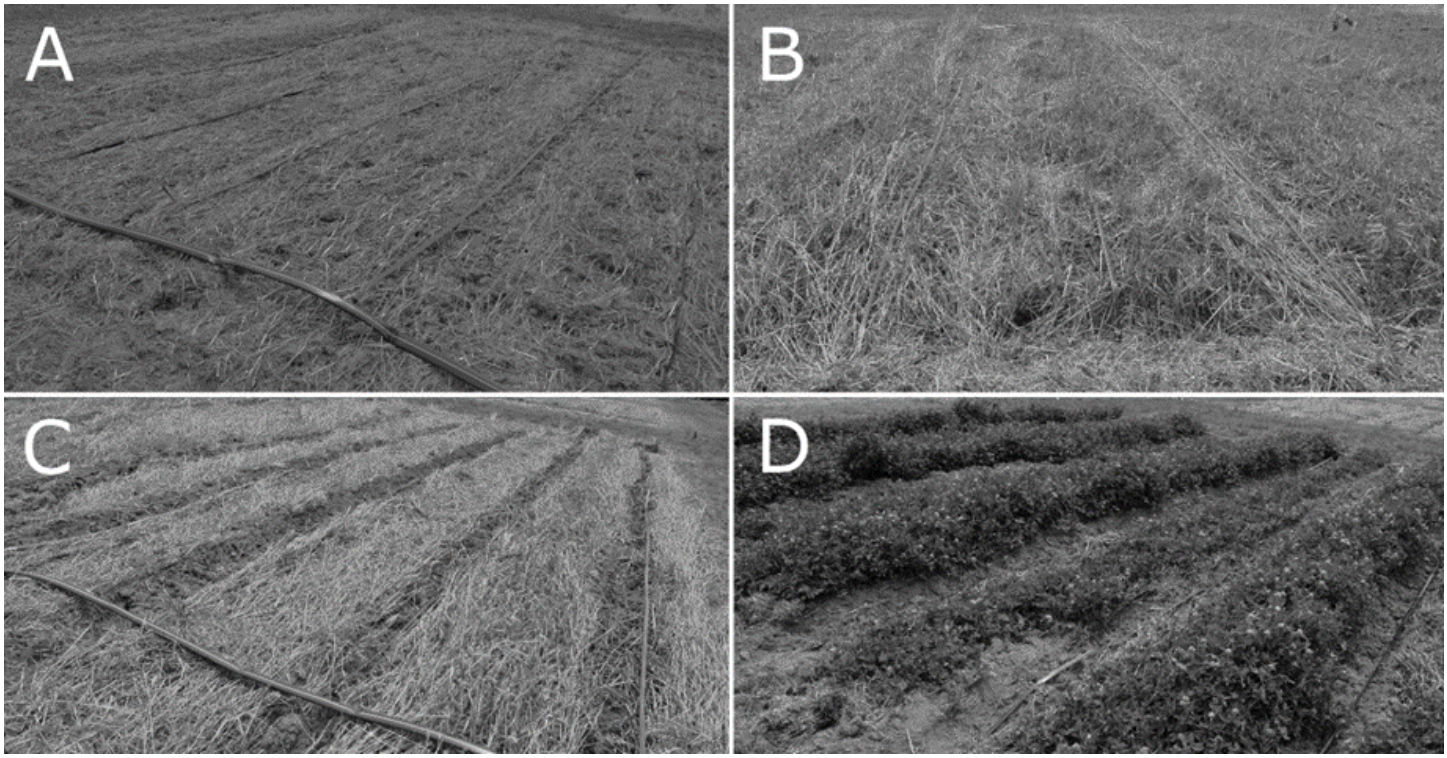


Figure 1. Four different ways of managing cover crops: (A) rye and crimson clover are flail mowed and incorporated using a rototiller, (B) rye and crimson clover are flail mowed and crops are planted directly into residue, (C) rye and crimson clover are roller-crimped and plant rows are strip-tilled, and (D) red clover living mulch is rotary mowed and plant rows are strip tilled.

TOIGO ORGANIC FARMS: HOW WE GROW TOMATOES

Kevin Matthews

Who we are….

Toigo Farms started as a family owned orchard located in Shippensburg Pa. When Mark Toigo took over he began driving fruit to DC farmers markets which allowed him to move more product and grow his business. Mark began the process of building our current growing facility over 10 years again and broke ground in May of 2014. Construction was completed in January of 2015 and plants were planted in December of 2014. Our head grower lives in BC and splits his time between home and PA to teach us how to grow in this environment. He has been growing for 30 years and growing organically for close to 10.

Our Structure….

The Toigo greenhouse is a state of the art 5 acre Dutch greenhouse employing sustainable and cost efficient technology. Starting with the mechanical side of things: We have the boiler and the heat storage tank. The heat storage tank is 250,000 gallons of hot water that we use to heat the greenhouse at night. The reason for the heat storage tank is so that we can have the boiler shut off at night and running during the day when we don't want the heat from the boiler but we do want the CO2 produced as a bi-product of burning natural gas. Running the boiler during the day allows us to divert the CO2 into the greenhouse through perforated poly-tubes while the plants are going through photosynthesis. This enriches the plants, gives us higher yield and reduces 'greenhouse' emissions. When the plants are shutting down and no longer calling for CO2 since they are no longer photosynthesizing the boiler is also shutting down, valves are repositioning, and transport pumps are moving hot water from the tank to the 14 miles of pipe in the greenhouse. We have the greenhouse divided into 6 compartments with no barriers but different controls for each compartment. This allows us to make adjustments to individuals areas in the greenhouse to account for variables like an intense morning sun that may heat up one end of the greenhouse or a strong wind cooler another side of the greenhouse. With the six compartments we are able to seamlessly integrate temperature differences to avoid problems like powdery mildew. The next and most important mechanical room is our irrigation room. Rainwater collected from the roof of our 5 acre facility is stored in a 750,000 gallon pond just outside the greenhouse and pumped into holding tanks as needed. The water is heated in the winter using heat generated by our boiler and cooled in the summer by mixing with well water. Once in the building we are able to regulate the pH of the water and mix it with our liquid fertilizer (about 10% of our fertilizer application). The water is then sent to the plants through drip irrigation. Once the water has leached through our soil beds it is gravity fed to a drain pit when we capture all of our drain water, it is then pumped into a holding tank where we can test, treat and reuse it. This water is then mixed with our clean water and sent back to the plants so that all nutrients stay in a closed loop until they are taken in by the plants. This keeps us from having to dump anything into the environment as well as get the most out of our fertilizers. Inside the building we have many environmental controls. The first of which is the 14 miles of pipe I mentioned before. Each row has a set of pipes running along the ground, these are our primary source of heat as well as our transportation within the rows. We have scissor lifts, push carts and seats that all ride on these rails for the crew to use when working the crop. We also have heating pipes that run in the lower canopy of the plants to help dehumidify the micro climate that is created within the foliage. This is run more in the summer than winter here is PA. The last system of pipes runs along our gutter system to help us to melt the snow off in the winter. We can cook these pipes up the 90° C and melt most snows off in just a few hours. We have a high wire system and grow our plants to a 15 ft wire and use the lean and lower technique to stay in continuous production for 9 months of the year on a single planting. Above the crop there are two important environmental controls. The first is the screening system. We have two screens that can be deployed on the interior of the build to cover the entire roof. The bottom screen is used as a shade screen and is similar to a large cloud moving in on a bright sunny day. The second is a thermal screen that helps to hold heat in at night in the winter since our glass roof does very little to insulate. The glass roof is made up of over 16,000 sheets of diffused glass which fractures the light as it passes through it. About half of these windows are on a vent which opens and helps us and the plants to cool the greenhouse.

How we grew…

Toigo Organic Farms is a 100% organic site. Indoors we primarily grow tomatoes but for the 2018 season we will be growing Tomatoes, Peppers, Eggplants, and cucumbers side by side in our controlled environment. We grow in biologically active soil relying on fungi and bacteria to make the organic, insoluble fertilizers available to the plant. We take leaf samples each week and send them away to Holland for analysis. This information is graphed for us week-by-week to allow us to determine trends and forecast upcoming deficient and over-abundant nutrients so that we can tailor our fertilizer regiments to meet the crops specific needs.

Bio-control program… (establish and maintain rather than eliminate and wait.)

Toigo Organic farms almost completely mitigates pest pressure using Bio-Control methods. We typically have every pest you will find in a tomato crop in some numbers but keep our predator and parasite populations high enough that the pest insects can never get to critical levels. We believe in establishing population and then maintaining them rather than trying to wipe out the pest and work in a sterile environment because for the way we grow it is just not a logical approach. For the 2017 season we spot sprayed about 1 gallon of suffoil-X over the course of 12 months. All other pest control methods were from biological or cultural controls.

USING BIOCONTROLS TO MANAGE APHIDS IN HIGH TUNNELS

Elsa Sánchez, Pennsylvania State University; Cheryl Frank Sullivan
and Margaret Skinner, University of Vermont

Aphids are a key pest of high tunnel crops causing several problems. When populations are high, they cause cupping and distortion of leaves, which stunts plant growth and fruit and flower formation. They also secrete honeydew, on which sooty mold can flourish. Some aphid species can also transmit viruses. Populations grow rapidly if undetected and can be an unsightly find to customers.

Using biocontrols to manage aphids can be an important part of an Integrated Pest Management 'IPM' approach. Scouting to determine the pest infestation level is a crucial step in using biocontrols successfully. Plant damage is often the first and easiest sign of aphids. Look for cupping and distorted leaves and honey dew. In addition, other evidence of their presence includes ants and cast skins of aphids. As aphids increase in size, they shed their exoskeletons which are called cast skins. These are white in color and can be confused with whiteflies. Ants and aphids can develop mutualistic relationships where the ants receive honeydew in exchange for protecting the aphids. When a lot of ants are present on a plant, check for the presence of aphids as well.

Record keeping is strongly recommended to keep track of when aphid and other pest outbreaks occur, the timing of biocontrol releases, and to assess the effectiveness of a treatment (biocontrol or insecticide). It starts with developing simple scouting forms. Sample scouting forms can be found on these web sites: https://pestmanagement.rutgers.edu/ipm/vegetable/scouting/ https://ag.umass.edu/vegetable/outreach-project/new-england-pest-scouting-network.

These forms should serve as a starting point and will be adapted to your operation. Other records to keep include maps of the tunnels with types and cultivars of plants grown and IPM strategies used. The species of aphids and its host plant, your personal tolerance for that pest and how you manage them will determine your action thresholds. An action threshold is the pest population level that you consider high enough to warrant treatment. For example, because it takes time for a natural enemy population to increase enough to combat an aphid problem, your action threshold for using biological control may be lower than for insecticides, which usually has a quick knockdown effect.

Every employee who works with the crop over the growing season should become familiar with aphids and other key pests and their biocontrols so they can alert you to an emerging problem. Personnel availability and time of year determines how often to scout. When starting out, you might want to scout each tunnel once a week. With experience you may change the frequency. More frequent scouting should be conducted when transplants are set or when seedlings emerge. Later in the season, every other week may suffice until plants are removed from tunnels. A set monitoring routine is ideal, however, whenever the plants are handled, scouting should be practiced.

Useful tools for scouting aphids include a hand lens, sticky cards, flags or flagging tape, bags and/or vials, and a camera. The hand lens allows you to magnify small items. A 10X magnification is generally sufficient. Sticky cards are useful for determining the presence of winged aphids and other flying insects. Start out placing 1 sticky card per 100 feet of row and adapt the number of cards to your situation. Replace sticky cards periodically when they get dirty. It's important not to rely only on sticky cards for monitoring. Aphids show up on cards after they develop wings, which is commonly in response to overcrowding on an infested plant. Aphids on cards usually indicate a severe infestation on the crop, which may reduce the success of a biological control treatment.

Elsa Sánchez is an Associate Professor of Horticulture in the Department of Plant Science at Penn State University. Her responsibilities are 60% extension and 40% undergraduate teaching. Current extension projects focus on sustainable and organic production of vegetable crops. She earned a BS in Horticulture and a MS in Agricultural Biology at New Mexico State University and a PhD in Horticulture at Washington State University. Elsa and her husband, Chris, live in State College, PA with their daughters Laurel and Lilly.

Plant inspections are needed to find non-winged aphids and other wingless pests that have not reached high enough levels on the crop to be detected on sticky cards. It's useful to scout two types of plants: random plants and flagged plants. For random plants, arbitrarily select plants to scout that represent the crop mix in the high tunnel. If you are growing different types of vegetables in your tunnel, scout plants of each type and cultivar. A starting point is to scout 1 plant in each 20 feet long section of row, which equals 5 plants in a 100 foot long row, for spring and summer crops including tomato, pepper, eggplant, and cucumber. Start out scouting 2 plants in each 20 foot long section of row or 10 in a 100 foot long row for leafy greens. As with the frequency of scouting events, the number of plants you scout depends on your situation.

If high pest populations are found on any random plants, mark them with a flag or flagging tape. This is a reminder to come back and check that plant during the next scouting event and to mark areas that may warrant treatments. You don't need to flag all plants with pests, only a few to help determine if your management treatments are working. This allows for you to monitor the numbers of natural enemies relative to pests and to determine the efficacy of a pesticide application.

Each pest has a preference for where within a plant to colonize. In addition to scouting a representative number of plants throughout a tunnel, it's also important to look within individual plants. This means scouting the tops and bottoms of leaves, and both old and new growth. We recently completed a research project investigating the use of biocontrols for aphid management in high tunnel vegetables. For that project, we scouted by visually dividing tomato plants into upper, middle, and lower sections and then examining the upper and lower surfaces of three leaves in each of those sections. For lettuce, we'd divide plants into outer, middle, and center sections and also examine three leaves in each section.

As a general rule, when using biocontrols, it is essential to properly identify what species of pest you have. Many natural enemies such as parasitic wasps are host specific, attacking a narrow range of species. When you are unsure of the identity of an insect you should collect several individuals and place them in a bag or vial or take a clear picture of it. Bags/vials and/or pictures can be sent to your local Extension Educator for identification. You can also purchase mixes of parasitic wasps, if you are unsure of what aphid species you have. Information about aphid id and biological control agents are available at http://www.uvm.edu/~entlab/High%20Tunnel%20IPM/HighTunnelIPM.html.

Other biocontrols for managing aphids include flies such as *Aphidoletes aphidimyza* and syrphids, predatory bugs such as Orius, lacewings, and lady beetles. It's important to know what life stage the biocontrol attacks and kills its host. For example, parasitic wasps and flies kill their hosts in their larval stages. The adult fly lays eggs around aphid colonies where their larvae/maggots consume the aphids. Several parasitic wasps lay eggs within aphids. Their developing larvae turn the aphid into brown or black "mummies". Predatory bugs and beetles are predatory as both adults and immatures. Selecting which biocontrol to use at a specific time depends on what aphid species are present, infestation level (high or low), environmental conditions, and time of year. It's also important to release biocontrols at the proper rate for the area in terms of pest infestation level. If you are unsure, contact your biological control supplier for general guidelines.

Dr. Margaret Skinner, a native Vermonter, is a Research Professor and Extension Entomologist, at the University of Vermont, Entomology Research Laboratory, where she has worked for 29 years, conducting research on management of a wide array of insect pests in forests, vegetable crops and greenhouse ornamentals. Her target pests include western flower thrips, hemlock woolly adelgid, Asian longhorned beetle, gypsy moth, conifer root aphid and tarnished plant bug. Much of her work has included development of strategies to maximize on the potential of insect-killing fungi. For 20 years she has also held a partial appointment as the Extension Entomologist, assisting greenhouse growers, landscapers and homeowners. She coordinates a regional interdisciplinary greenhouse IPM program, linking specialists from ME, NH and VT, which has resulted in a significant increase in growers' use of non-chemical IPM approaches. Prior to pursuing advanced degrees in entomology at the University of Vermont she worked for over 12 years in sociology and human services.

We recently completed a 3-year experiment focused on using habitat plants and banker plants in a biocontrol program to manage aphids in high tunnels. Habitat plants, such as alyssum, promote the establishment of natural enemies and encourage them to come in from outside the high tunnels. They provide pollen and nectars to adults of several biocontrols that require floral resources to reproduce. They can also provide attracted pests/hosts. Caution should be used to make sure these systems are not attracting too many unwanted pests then act as a source to the crop. That is another reason why routine scouting should be exercised.

Success when using biocontrols to manage aphids relies heavily on finding the problem before they reach damaging levels. Early intervention is crucial to release biocontrols so they can become established at the onset of an issue. Monitoring aphids and biocontrols after releases are made is essential to observe biocontrol efficacy and to determine if additional releases are needed or an insecticide application warranted. Over time, your biocontrol plan will be adapted to reflect your specific operation and your experiences. Allow time to fine-tune your plan.

HEAT TREATMENT OF VEGETABLE SEED FOR DISEASE MANAGEMENT

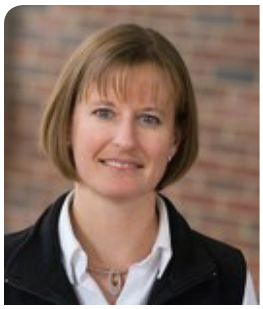
Beth K. Gugino
Department of Plant Pathology and Environmental Microbiology,
The Pennsylvania State University
204 Buckhout Lab, University Park, PA 16802
bkgugino@psu.edu

The heat or hot water treatment of vegetable seed is a tactic best used as part of an integrated pest management program for disinfesting seed of pathogens (primarily bacterial as well as fungal). In the heat treatment process, the pathogens that are associated with the surface as well as underneath the seed coat are subjected to killing temperatures. However, hot water treatment will not kill pathogens associated with the seed embryo nor is it effective against viral pathogens.

Although the process itself is simple, careful attention to detail is required otherwise seed viability maybe greatly reduced or the treatment may be ineffective. Seed which is pelleted, has previously been treated or is old or of poor quality should not be treated. If treating a large batch of seed, it is recommended that a small lot/batch of seed is treated first to determine the potential effect on germination.

The basic steps are as follows:

1. Place the seed loosely in weighted cheesecloth, fiberglass screen envelopes, coffee filters, nylon stockings, or tea infusers. Be sure to adequately label the each package because once treated they cannot be reintroduced back into the original packaging. This is especially important when treating multiple cultivars of the same crop at the same time.
2. Warm the seed by soaking it in a 100°F (37°C) water bath for 10 minutes (pre-treatment step).
3. Transfer the seed to a more precisely temperature controlled water bath based on the temperature and time durations found in Table 1. Make sure that the packets are fully submerged and use an aquarium bubbler to keep the water agitated to prevent "cold" pockets or other uneven heating.
4. Remove the seed packets and rinse in cold water for 5 minutes to cool the seeds. Use paper towels to blot excess water and then spread them evenly on a clean paper towel or sanitized drying screen to dry.



Beth K. Gugino is an Associate Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University located at University Park, PA. Her extension and research program focuses on the identification, epidemiology and management of vegetable diseases important to the Pennsylvania and the Northeast region. She received her B.S. in Horticulture and M.S. and Ph.D. in Plant Pathology from The Pennsylvania State University. She was a post-doc at the New York State Agricultural Experiment Station with Cornell University working with diseases of vegetable crops and soil health for four years before returning to Penn State in June 2008.

Table 1. Recommended time and temperature treatments for the hot water treatment of select vegetable seed.

Type of Seed	°F	Minutes soaking
Broccoli	122	20-25
Brussels sprouts, cabbage, celery, celeriac, eggplant, spinach, tomato	122	25
Carrot	122	15-20
Cauliflower, Chinese cabbage, collard, cucumber only, kale, kohlrabi, rape, rutabaga, turnip	122	20
Garlic	120	20
Lettuce	118	30
Mustard, cress, radish	122	15
Onion	115	60
Pepper	125	30
Shallot	115	60

ADDRESSING ISSUES WITH HIGH SOLUBLE SALT LEVELS IN HIGH TUNNELS

Elsa Sánchez, Professor of Horticultural Systems Management
Tom Ford, Senior Extension Educator, Horticulture
Pennsylvania State University Department of Plant Science and Extension

We have been working to determine the extent that high salt levels in high tunnels are a problem, offering solutions to manage the problem, and developing resources for avoiding the problem. We proposed to analyze soil and irrigation water from 50 organic and conventional high tunnels throughout Pennsylvania. To date, we have contacted 55 high tunnel farmers throughout Pennsylvania to see if they would like to be involved in our project. Thus far, 25 farmers from 17 counties across Pennsylvania have agreed to participate. Participants have been conventional to organic and represented many groups including women and men and Anabaptist and English farmers of varying age groups. Participants have completed a brief survey on their high tunnel practices. Then, they received prepaid soil testing kits including organic matter and soluble salts analysis and irrigation water testing kits. Additionally, return postage was provided for all soil and irrigation water kits. By individual, testing and postage has amounted to about $100. We had intended to visit 15 farms for on-site discussion and analysis of high tunnel soil and irrigation water quality; however, we forgot to include postage in our original budget. Therefore, we decided to forgo this portion of the proposal in order to maximize the amount of farmers who could participate in the project.

Soil and irrigation water has been analyzed by Penn State's Agricultural Analytical Services Laboratory. Once we receive reports and surveys, we have written letters to each participant with an interpretation and recommendations specific to their farm. Each letter has been 2 or 3 pages long and has also included enclosures. The most common issues have been high soluble salt levels and phosphate, potash, calcium, and/or magnesium levels exceeding crop needs. We have provided recommendations for reclaiming saline soils as well as for preventing increasing soluble salt levels levels. We have also offered recommendations for decreasing above optimal nutrient levels as well as for supplying nitrogen to high tunnel crops. The most frequent problems with irrigation water quality have been with high pH, alkalinity, and/or hardness. We have provided recommendations for acidifying water and for remedying issues with plant growth in surface water.

Through this project we have learned a lot about high tunnel soils and irrigation water quality. To further extend this information, we are going to be presenting results and recommendations from this project at the 2018 Mid-Atlantic Fruit and Vegetable Convention and Farming for the Future Convention. During these presentations we will solicit more participants in an effort to reach the 50 we proposed. We also plan on sending a final report to all the participants with a summary of everyone's results. We will also develop articles on managing high tunnels soils and irrigation water to post on the Penn State Extension website.

Elsa Sánchez is an Associate Professor of Horticulture in the Department of Plant Science at Penn State University. Her responsibilities are 60% extension and 40% undergraduate teaching. Current extension projects focus on sustainable and organic production of vegetable crops. She earned a BS in Horticulture and a MS in Agricultural Biology at New Mexico State University and a PhD in Horticulture at Washington State University. Elsa and her husband, Chris, live in State College, PA with their daughters Laurel and Lilly.

Thomas Ford has worked for over 35 years with Cooperative Extension in Maryland, North Carolina, and Pennsylvania. During his career he has worked intensively with vegetable and fruit growers, greenhouse and nursery operators, landscape and turf professionals and area farmers with their production and pest management issues. Tom is a native of Central Maryland and resides with his wife, Laura and their four sons in Duncansville, PA. Tom has a B.S. degree in Ornamental Horticulture from the University of Maryland and a MBA from Frostburg State University in Frostburg, MD. Tom currently serves as a Commercial Horticulture Educator with Penn State Extension and is housed in the Cambria County Extension Office in Ebensburg, PA. -2016

GROWING RHUBARB IN COLORADO

Dennis Duncan
Owner/Chief Sodbuster

Donna Duncan
Owner/Nurseryman

High Altitude Rhubarb—Organic Farm & Nursery
7275 Wildridge Rd.
Black Forest, CO 80908
(719)494-8424
Dennis.Duncan@HighAltitudeRhubarb.com
www.HighAltitudeRhubarb.com

This presentation shares the main lessons from 15 years of organically growing rhubarb in Black Forest, Colorado. We will first give an overview of our farm and then discuss relevant generic aspects of growing and marketing rhubarb. Then we will cover details of growing rhubarb relatively unique to our farm. Lastly, we will present our nursery experiences. Additional information is available at our website, www.HighAltitudeRhubarb.com.

The Farm

High Altitude Rhubarb is a certified-organic hobby farm at 7700' in the zone 4-5, semi-arid climate of Black Forest, Colorado. First harvest was 2008. We sell fresh rhubarb and rhubarb plants. We also sell horseradish plants. Current rhubarb plantings should yield 7000 lbs. at full maturity…less than an acre planted. Current market price is $3.50/lb. Many plants are still too young for commercial harvest. Current output is about 3000 lbs. We sell rhubarb directly to the public and food processors via pick-your-own events at the farm. In 2018 we suspended shipments of rhubarb and plants, local demand now takes our entire crop. (Details of our sales and marketing will be presented in separate talk, *Agritourism at High Altitude Rhubarb.*) A few hundred plants are sold at the farm while much larger numbers are licensed for growth and sale by others. The farm is a two-person, part-time endeavor. However, a dozen helpers join in the harvest festival and one or two others sporadically during the growing season. We grow a twenty varieties of rhubarb, half from overseas and some unique to our farm, and two varieties of horseradish, one unique to our farm. However, most product comes from three varieties of rhubarb.

Rhubarb in General

Rhubarb is a late-spring vegetable. (Some US courts have declared it a fruit. Rhubarb seems indifferent to our confusion.) Varieties are first categorized based on the external color of the stalks, red or green. Partially red stalks, grading from light red at the base to green at the leaf, are considered green. Black, purple and even desert-dwelling varieties are also known. The market appears to be growing, though it has yet to approach pre-WWII levels.

There are several important facts relevant to considering rhubarb as a crop: leaves are toxic; cultivar names are non-standard; herbivory, diseases and insect damage are uncommon; zone 5 or colder is required; many varieties, easily hybridized with wide variations in characteristics; organically rich, well drained soils are ideal, ripeness is signaled by size and leaf maturity, not color; and, the plant is high adaptive but each variety has its own optimal environment.

Dennis created and, along with his wife Donna, owns and operates High Altitude Rhubarb—Organic Farm and Nursery, in Black Forest, CO. A baby boomer, born in '49 in Albuquerque, NM. Raised in Albuquerque and LA, a city boy until age 40. Has lived and worked in NM, CA, NH, TX, MA and CO. Life paused by the Vietnam War, he was a Korean interpreter for NSA. Attended U of MD, U of WA and graduate from the U of NM in Math, BS, and Computer Science, MS in 1978. His computing career saw him as a department chair, engineering and product development manager, director and exec at UNM, Digital Equipment Corporation, Apollo Computer and Eastman Kodak, respectively. His teaching career included UNM, U of Colorado, and Pikes Peak Community College. Moved to Colorado where he says he taught part-time and mismanaged his investments. Trying to find something useful and fun to do with his 6 acres he started the farm in 2002. Current hobbies are dominated by the farm, working and researching farming and rhubarb. To quote him: "It is a rare day when I don't learn something new. Of course, at my age I could be re-learning the same thing every day, how would I know?"

The important marketing considerations for rhubarb are: 1) color, red is ideal, but our primary crop is green; 2) freshness, organic rhubarb has a shelf life of 7-10 days; 3) organic/non-organic, the organic market premium is up to 100%, and 4) season, most demand is in early spring.

Growing Organically in Black Forest

Like many farmers, we face some challenges and opportunities unique to our location. Our climate is hostile to most forms of agriculture, water is in short supply, and there is a wealth of inexpensive forest products available. Adding the fact that we are pushing 70 and slowing down, we came up with the following approach to growing rhubarb organically. It is a till-once approach which should provide acceptable production for at least 2-3 decades. Most expense and labor apply to the initial preparation and planting. Maintenance and annual growing activities are relatively small. Lastly, our growing approach necessitates plants be a few years old before commercial harvest. Picking from young plants slows their growth as they are deprived of the energy from the picked stalks and expend additional energy replacing picked stalks instead of root expansion.

We plant the farm in plots of 25 to 80 plants per plot. 80 mature Victoria plants should produce about 5000 lbs. of rhubarb. Virtually all other varieties produce less. Plots may be adjacent to other plots or isolated. The farm layout is influenced, in part, by our pick-your-own venue. Plots are surrounded by 6'-10' walkways with plants growing in rows on islands in a sea of very deep mulch. Plots are created as follows:

1) The top 6" of soil is heavily amended by tilling and/or disking in mature compost.
2) Each plot is surrounded by a walkway at least 6' in width. A layer of ground cover is laid to define this walkway. This is primarily a barrier to weeds and offers easy access for equipment and people.
3) The newly enriched soil is mounded to 18-36 inches, 4-8' apart on center, depending on the rhubarb variety, and the top of the mound is leveled to 12" in diameter.
4) Mounds are surrounded in a sea of pine mulch a few inches higher than the mounds. It will compact and compost in place. Walkway mulch, a weed barrier, is 2"-5" deep.
5) Mounds are topped with mature compost, formed into a water ring.
6) One rhubarb root is planted in the center of each mound.
7) Over time the mulch and mounds both settle to a minimum depth of 12".

It took several days tractor work and $2,400 in materials to prepare a 1/3- acre plot 3' deep with plants 8' apart on center. It took 40 yd^3 of compost (we don't make our own, no animal husbandry), 400 yd^3 of mulch, 400' of 6'-wide ground cover. Mature, large plants require 150 gallons of water to produce 60 lbs. of rhubarb. Mother Nature provides almost no water during the growing season…much of our moisture is in the form of snow.

Maintenance and annual activities involve:

1) Each fall the plants go dormant, dead debris is removed and the top of the mounds are covered in a 2" layer of compost.
2) Just as growth appears (March/April) the compost is pulled back, by hand, to form a new water ring
3) Plants grow about 2 months and are harvested at about 70% full growth.
4) Every 5-7 years it is necessary to top off the mulch with another 3-5" of mulch as it composts and settles in place.
5) Semi-arid climate, we deep water the plants 4-5 times per year, flooding the water rings.

Soil tests reveal that the mulch composts in place to produces soil similar to our native prairie soil, which is inadequately shallow but with adequate nutrients except nitrogen. While initial production used tiller, wheel barrow and shovel, we have since perfected ways to use a small tractor for most farm work.

Yield is about 4500-6500 lbs. of rhubarb per acre, depending on variety. We sell for $3/lb to volume pickers and $3.50/lb. to the public. An additional $0.50/lb. if we pick it. Sell out each year. The farm requires two man-months of outdoor effort and another man-month of administration (maintaining website, emails, phone, paperwork…). Expansion would require more outdoor manpower but the additional revenue would more than fund paid help, resulting in the opportunity to reduce our own manual contribution, if desired. Such expansion is underway.

A Rhubarb Nursery

Our plant nursery offers 15-months-old potted, organic rhubarb plants for local sale. Most are picked up during our pick-your-own harvest. Although growing a score of varieties, we currently sell only Victoria, Canada Red and Turkish plants, because those plants provided seeds. Victoria, the most popular plant, and Turkish, the least popular, are very hardy; Canada Red is prone to a debilitating fungus characterized by red spots on the leaves. We plan to replace Canada Red with pure red varieties from Australia once their hardiness is established and with our own, proprietary Colorado Red.

Starting plants from seed is both lengthy (15 months) and requires almost daily attention from March to July, then weekly to October. It is necessary to start three to four times more seeds to produce the number of plants desired.

Over five years the germination rates have declined from initial rates of about 90%. The age of the seeds (harvested in 2011-2913) could be a factor. Furthermore, Victoria seedlings show an increased susceptibility to fungal infections.

It takes about 133 hours to perform the seed to plant process, with potting taking about four hours for every 20 plants. In addition, time is spent emailing customers of plant availability, taking orders, tracking prepayments, which guarantees the customer a plant, and producing a master list of customers, their plants, payment arrangements and pickup date. Customers may also need advice. This mostly computer mediated job lasts about six weeks and takes approximately 10 hours.

Our materials are all USDA certified organic or are OMRI and approved by One Cert. We use Black Gold Seed Starter medium in seed trays, warming mats under the seed trays, large 6-packs, 1.6 gallon pots, water soluble nitrogen fertilizer, ProMix MP potting medium, pearlite, and compost. The total cost per pot is about $3.83.

We charge $15 per plant. Costs are approximately $3.83 per plant. On site farm sales were 131 rhubarb plants and 22 horseradish plants in 2017. Net revenue from plant sales was $1,463. Third party sales are confidential.

HOW WE EXTEND OUR RHUBARB GROWING SEASON IN ONTARIO

William I French
Lennox Farm (1988) Ltd.
518024 County Rd. 124,
Melancthon, Ontario
L9V 1V9
E-Mail: lennoxfarms@hotmail.com

BRIEF HISTORY

Rhubarb is a member of the buckwheat family, Genus Rheum. Rhubarb is a perennial, the below ground portion is a fleshy rhizome and fibrous root system. The petioles or stem is used for food and the leaves are poisoness with oxalic acid but may be used for an insecticide. Rhubarb is a vegetable but in domestic use is considered a fruit. Turkish rhubarb was first grown in Asia 5000 years ago, using the dried root for medicinal purposes. It was grown in Europe in the 1700's and was first recorded as a food in 1778. By 1820 a method of forcing rhubarb in the dark developed into producing rhubarb in the winter months.

VARIETIES:

About 50 species of Rheum are known. Rhubarb has a wide range of colour and texture ranging from pale green to dark red. The red petioles are preferred for fresh market in North America. The greener varieties are used for processing in the winter. We grow Victoria and Sutton for the forcing sheds and Canada red and German Wine for fresh market sales. We also have some trials of a couple of other varieties.

SOIL TYPES;

Rhubarb prefers a rich loamy soil with good drainage. It likes lots of water but dry feet. It will grow in a variety of soils but some species are particular to certain soil and climate.

PLANT SPACING AND POPULATION;

Population can vary between 4000-7000 plants per acre. For fresh market a higher population will give you more yield and smaller plants and petolias. For forcing rhubarb less population gives bigger roots with larger petolias for forcing inside. Our spacing is 36 in. rows, plant spaced 20-36 in. in row depending on variety.

NUTRITION;

Rhubarb requires heavy amounts of nitrogen as high as 300 lb/acre of 33% and cattle manure if available @ 20 tons per acre preplant. Phosphorus is important the first year for root growth and Potash levels should be kept up. PH should be 6.0-6.8. Apply high calcium lime (Gypsum). Soil tests are required.

WEED CONTROL;

Start with clean field. Grow cash crops like corn that have good weed control. Incorporate Devrinol or Treflan PPI. Spray with Dual after planting. Start cultivating and hand hoeing when weeds first show. Plant on the square if possible and cultivate both directions.

William (Bill) French and his family own and operate Lennox Farm (l988) Ltd. in southern Ontario approximately 110km north west of Toronto. Bill's family has been growing rhubarb since 1890. Lennox Farm (1988) Ltd is the largest grower of rhubarb in Ontario with about 70 acres. We also grow 75 acres fresh market garden peas, 20 acres of brussel sprouts and small amounts of asparagus, sweet corn and strawberries to support our roadside retail market. Bill and his son Brian over see the farming operation and the wholesale produce sales. Bill's wife Diane looks after the office. Jeannette (Brian's wife) is a full time teacher and manages the retail market for the farm. Their three young children are eager to help out and learn the business.

FORCED RHUBARB;

We use Victoria Rhubarb for our first building because it grows at a lower temperature 10 deg. C. Our buildings that we force in March, April and early May we grow Sutton Rhubarb because it will hold a red colour at a warmer temperature 11-13 deg. C.

The roots are grown in the field for two or three seasons and not harvested during the summer. We dig them in October or early November and fill the buildings on the floor (dirt floor preferred). The Rhubarb root must have a dormant period for at least 30 days of around 3 deg. C before it can force inside. Gibberellic acid will help bring rhubarb out of dormancy and increase yield on a early crop to harvest by January 1st. We turn the heat on in each building about 5 weeks apart from late November till late March to force the buildings following each other. The Rhubarb grows in the dark, growing about an inch daily. We harvest twice weekly. Forcing in the dark gives the rhubarb a beautiful pinkish red colour. Care must be taken harvesting forced rhubarb because it is very tender.

MARKETING;

Forced rhubarb is all sold for fresh market packed in 10 lb. Boxes (20 lb. In USA). Our distribution goes through the Ontario Food Terminal at a Brokerage house. We also supply restaurants and chain stores through distributors. Field rhubarb in the spring and summer is sold fresh through the same system. Other markets are processing for bakeries, supplying wineries and micro brewers.

All our crops are monitored under the Food Safety program Canada GAP (good agricultural practices). We keep records from planting, fertilizer, sprays to harvest and shipping. Our family is all involved in record keeping and employee training for food safety and workplace safety standards.

Growing Rhubarb is a long term investment. With good management 0and hard work it can be a profitable crop to grow.

HOW WE DO KALE

Richard Calimer, Scenic View Orchards
16239 Sabillasville Rd., Sabillasville, MD 21780

Plants and varieties:

- Winterbor and dinosaur kale
- Plants are started in 128 cell count trays
- Kale is transplanted 6-7 weeks after seeding
- Plants are around 4 inches tall and are hardened off before planting

Preparing fields for planting:

- Select a field based on 4 year rotation
- Plow ground in the fall
- Disk and harrow after soil is dry enough in spring
- Apply fertilizer 100-80-150, sulfur 10 lb., boron 1 lb., zinc 1 lb.
- Raised beds, 4 foot embossed black plastic, single drip tape in middle of row

Planting:

- April 1st and June 1st, planting twice per year
- Plant double rows 24 inches apart (staggered), with rain flow water wheel planter
- April crop covered with remay cloth to warm soil temperature
- Use hoops spaced 8 ft. apart with agribon-19 row cover over the hoops

Maintenance of plants:

- Water weekly
- After removing remay (May 1st) thin plants one per hole and weed around plants by hand
- Spray Gramoxone in between plastic (May 1st and June 1st)
- Spray foliage if insects are observed (tombstone or radiant)
- Fungicide available (fontelis and zampro)

Harvesting and marketing:

- Pull lower rosette's off of upright stem starting around May 5th
- Pick early morning into bushel box lined with bushel poly liner or 1-1/9 bushel wax box
- Cool down immediately after harvest, sprinkle with water if no dew that day
- Sell at farmers markets and roadside market $3-$4 per lb.
- Wholesale $1.50 per lb.
- Continue to harvest plants up through January

Richard Calimer is involved with four other families in operating Scenic View Orchards, the seventh generation returned to the operation this past year. He has a bachelor's degree in agribusiness from the University of Idaho in Moscow, Idaho, and returned to the family business in 1990.

BUTTERBEE FARM: SUSTAINABLY GROWN FLOWERS FOR BALTIMORE

Laura Beth Resnick, Butterbee Farm

Butterbee Farm is a 2 acre flower farm in Baltimore County, just over the city line. Laura Beth Resnick started the farm on an urban lot in Baltimore City in 2013, on 1/13th of an acre. The following year, she found land to lease in Pikesville, Maryland.

Money was tight, so using crowdfunding through Indiegogo (a crowdfunding platform) she bought basic tools for the farm such as shovels, hoes, and a shed. In subsequent years she received the VAPG grant to produce herbs for restaurants, the Fruit Guys grant, and the EQIP grant to build a high tunnel. She also participated in the Beginning Farmer Training Program through Future Harvest CASA, which provides a small stipend to trainees.

From the first year, Laura Beth collaborated with a floral design studio in Baltimore called Local Color Flowers. More affectionately known as "Locoflo," the studio sources 100% locally and therefore relies heavily on producers close to the city. Since she started the farm, Laura Beth and Locoflo owner Ellen Frost have worked together on projects like workshops and classes, speaking at conferences about farmer-florist relationships, and even writing a column for the Association of Specialty Cut Flowers Quarterly.

Local Color Flowers is one of about 75 florists on Butterbee Farm's availability email list. Florists are the farm's biggest channel, followed by weddings. Butterbee Farm does not provide floral design services, but they do offer bulk flowers to brides and grooms who want to DIY their wedding flowers. In 2017, Butterbee Farm provided flowers for 30 weddings. Butterbee Farm also has a small CSA program through which fresh flowers are delivered directly to members' homes.

Events and agrotourism are an important channel for the farm. Several Saturdays each summer, the farm is open from 9 to 11 am for visitors to tour the farm with Laura Beth and make a bouquet to take home from pre-harvested buckets of flowers. The farm also hosts several design workshops in collaboration with Local Color Flowers, such as Lavender Class and Headcrown Class. In 2018, the farm will host a new workshop called Creative Entrepreneur, a small business workshop for women taught by business leaders all over Baltimore. Also in 2018, the farm will host its fourth all day farmer-florist workshop, called Blooms and Bouquets.

Growing practices are always evolving at Butterbee Farm. Currently, all flowers are grown in permanent raised beds, built with the BCS walk behind tractor. Sileage tarps are used in between crops in place of tilling or herbicides. No synthetic fertilizers are used; the farm relies heavily on compost and fish emulsion. The farm is irrigated from a fire hydrant on the road.

Infrastructure includes two high tunnels, a propagation house, use of the property's barn, and a walk-in cooler. The farm has access to the property's tractor and front loader as well. In early 2017, Laura Beth and her husband Jascha became the groundskeepers of the larger farm property, allowing them to move to the farm. Living at the farm means much more freedom to expand; in 2018, they will build a heated greenhouse for winter growing.

Major crops include dahlias, ranunculus, greenery such as mint and dusty miller, and woody perennials such as mock orange and ninebark. The crop plan is driven directly by floral design trends; each winter, Laura Beth sits down with her top customers to learn what they'd like to see more of the next year, and what flowers and colors they think are trending. Sunflowers, zinnias, and celosias are grown more for weddings, CSA, and on-farm events than for floral design use.

Laura Beth Resnick is the owner of Butterbee Farm, a two acre flower farm just outside of Baltimore City. Butterbee Farm flowers are for florists, weddings, and CSA members; the farm is also home to classes and workshops. Before she was a farmer, Laura Beth went to music school to study flute performance, which prepared her well for entrepreneurship. Laura Beth is a Trainer through the Beginning Farmer Training Program with Future Harvest CASA, and President of the Maryland Cut Flower Growers Association. She has taught numerous workshops and is a speaker on the subjects of crop planning, business relationships, and more at regional and national farming conferences.

For the first four years of the business, Laura Beth worked on the farm with her husband Jascha Owens. Now that the groundskeeping job keeps Jascha busy, Laura Beth has several part time employees. In 2018, she will bring on her first full time employee, who will hold the position of Crops Manager. The plan is for the Crops Manager to be responsible for keeping the crop plan on schedule, so that Laura Beth can focus more on sales and big picture management.

For more information on the farm, please see www.butterbeefarm.com. Upcoming events include an all day farmer-florist workshop called Blooms and Bouquets (save the date for Monday, July 23) and a small business workshop for women called the Creative Entrepreneur (March 26, register at butterbeefarm.com/creative). Follow the farm on Instagram at butterbee_farm.

HOW WE GROW AND MARKET ROOTS

Chris Brittenburg, Who Cooks for You Farm

A caveman's approach to organically growing and marketing roots.

1. Field Preparation

   Primary tillage - Incorporate cover crop 2-4 weeks before direct seeding.

   Secondary tillage – Disk 2-3 times

   Finishing tool – Perfecta 2 times.

   Williams Weeder for long term stale bedding.

   New recruit: Forigo rock burier

2. Direct Seed

   Tool: Sutton Ag Junior

   Crops: Carrots, Beets, Turnips, Radishes

(we, also, grow Garlic, Onions Potatoes)

3. Weeding

   First time through we use a Basket weeder

   Second time we use a Basket weeder and the Williams Weeder

   Third time we use the Williams Weeder

   Fourth time we use shanks and knives

4. Fertility

   Broadcast fertilize before the last shallow cultivation preparing the field.

   Broadcast fertilize again or side dress in approximately 3 weeks (150-200#/ acre)

5. Spacing

   Increase space between roots in general (quick growth)…get'em out get'em out..

   Tight for those crops where demand is for small roots (radish, salad turnips…)

   Demand for small roots with greens on the up with restaurants.

6. Grading in storage (a bit…)

7. Harvest

   Bed Lifter For Carrots

   Bunch

Chris Brittenburg grew up in Bethlehem, Pa. He went on to college and then traveled about in the US and elsewhere. Approaching his 30's and needing a profession, he decided farming was the air under his wing. With a few years farming under his belt, he met Aeros at a farming conference, fell head over heels and set up to farm on Aeros' family farm. He manages our on farm systems. He calls himself "the machine". He's the director of actions that organizes all the moving parts in the greenhouse, pack shed, and field. From sowing seeds to harvesting fruits he keeps everything moving synergistically.

8. Early season Transplants on green plastic (beets)
9. Washing of roots (barrel washer, TEW)
10. Storage

    Main season

    Winter

Marketing: Trends to pay attention to…

Restaurants, Farmers Market, Wholesale, CSA

-We bunch roots and top roots.

-Bagging roots (carrots especially) for wholesale and market 2# each sale

-Certified Naturally Grown shown with organic in stores if bagged.

-To our restaurants, we try to sell those items that are difficult to sell at markets (baby beets and baby carrots for example)

-in general we try to sell roots that are the same size. Seems to be more appealing to market goers and chefs.

- small radishes, carrots and salad turnips with greens to restaurants.

SWEETPOTATO PRODUCTION IN PENNSYLVANIA

Michael D. Orzolek
Prof. Emeritus Vegetable Crop
Penn State University

Sweetpotatoes grow optimally in well-drained sandy and sandy loam soils. Avoid planting sweetpotatoes in heavy soil types and soils with high organic matter that could promote scurf on the tubers. Three to four crop rotation years between sweetpotato crops are encouraged to reduce the incidence of soil-borne diseases. Test soil for nematode populations and fertility.

Many consumers think of sweetpotato flesh color as orange and so the following orange flesh varieties are recommended: Beauregard (FR), Covington (FR + RKR), Evangeline (FR + RKR) or Orleans (FR). For growers marketing specialty vegetables, two white flesh sweetpotatoes are recommended; Bonita (RKR) and O'Henry. The two abbreviated disease notations are FR-fusarium and RKR – root-knot nematode resistance. Growers have the option of buying "slips" (sweetpotato transplants) from commercial growers or growing their own slips. Since sweetpotato plant populations range from 8,700 plants/A (4 ft x 1.25 ft plant spacing) to 18, 600 plants/A (3.5 ft X 0.7 ft plant spacing), most growers will produce all or a majority of the slips they need for their production fields.

For slip or transplant production, only select tubers that are true to varietal type (no off types), free from insect and disease damage and have a uniform, bright skin color. Quality sweetpotato transplants are not produced from **poor quality** sweet potato tubers. Prior to placing tubers in plant (seed) beds to produce slips, it is recommended that the sweetpotato tubers (seeds) for transplant production be pre-sprouted at 85°F and 90% relative humidity for 3 to 4 weeks or until sprouts are 1.0 to 1.5 inches long on the tubers. During the pre-sprouting period, sweetpotato tubers require plenty of oxygen for optimum slip production. Keep the sweetpotatoes for pre-sprouting in a well ventilated storage and replace the air at least two times a day.

Apply 4 to 5 pound of 8-8-8 or 10-10-10 per 100 square feet of bed area. Approximately 1,000 to 500 slips can be produced from 1 bushel of sweetpotato tubers in 15 to 20 square feet of bed area. After presprouting the tubers, place them into the beds, being careful not to damage the sprouts. Treat the presprouted sweetpotato tubers with a fungicide to prevent bedding root decay. Be sure to cover the tubers completely with 2 to 3 inches of coarse soil (preferably sand). Keep beds moist, **but not wet**. After planting the sweetpotato tubers in the bed, cover the bed immediately with black or clear plastic film to warm the soil. The optimum temperature for producing sprouts from seed tubers in beds is 75° to 85°F. Slips are ready to harvest when they have 6 to 10 leaves and strong root system. To harvest slips, cut them about 1 inch below the bed surface to prevent contamination from the seedbeds from moving into the production field. Clean knives frequently by dipping them into a 1:1 (volume to volume) solution of bleach and water. This will also prevent the spread of diseases from the seedbed into the field. Transplant the slips as quickly as possible after harvesting from the plant beds to insure plant viability.

Avoid planting slips until all danger of frost is past since sweetpotato slips are **very frost sensitive.** Field beds should be 4 to 8 inches high and as wide as equipment will allow. For cooler growing regions in Pennsylvania, it is recommended that sweetpotatoes be grown on raised beds with black plastic mulch and drip irrigation under the mulch. Sweetpotatoes require a total of 75 lbs/A N-P-K either applied prior to making beds or split with some fertilizer broadcast and the remaining amount injected with drip irrigation. Narrow beds tend to dry quickly and may reduce

Michael D. Orzolek is Professor Emeritus of Vegetable Crops, Department of Plant Science, The Pennsylvania State University. He came to Penn State in 1981 with a three-way appointment – 60% Extension, 22% Research and 18% Teaching. Since his retirement in July, 2012, he has kept active conducting applied field research and moving his office to the Horticulture Research Farm, Rock Springs, PA. He has done extensive research on stand establishment, plastic mulches, high tunnels, weed management and tillage systems. Mike is still the current Director of the Penn State Center for Plasticulture and the CP High Tunnel Research and Education Facility at Rock Springs, PA..
Dr. Orzolek formerly was Extension Vegetable Specialist at the University of Delaware (1974-81). He received his B.S. in Biology from Alliance College, his M.S. in Horticulture from West Virginia University, and his Ph.D. in Horticulture/Botany from the University of Maryland.

overall yields. High beds will aid in promoting drainage, thus preventing water damage to roots. A high phosphorous starter solution such as 10-52-10 is recommended for application while transplanting sweetpotato slips into beds. Prior to transplanting the sweetpotato slips, a light irrigation of 0.5 to 0.75 inches of water will help establish young slips by providing a ready supply of water to young developing roots. Although sweetpotato are deeply rooted and drought tolerant, they still require sufficient moisture to grow and produce quality roots. Soil water fluctuations can cause the development of small or misshapen roots. In either case, defects will make sweetpotatoes non-marketable. Excessive moisture can cause vigorous vine growth and undesired elongation of roots. The most critical moisture requiring period for sweetpotatoes is during root expansion and 40 days prior to harvest. Sweetpotatoes require approximately 1 inch of water per 3 weeks.

Mechanical vine killing (devining) 5 to 7 days before harvest improves skin set and facilitates harvest. **Harvest sweetpotatoes before a hard frost in the fall.** Various methods can be used to harvest sweetpotatoes. Growers with a small area may harvest by hand by using a garden fork. Use gloves to keep bruises and abrasions to a minimum. Intermediate sized commercial growers can use a one row modified mold board plow or middle buster with a notched coulter adjusted just left of the main stems to turn the rows and expose the storage roots. Roots are removed from the vines by hand and placed into smooth baskets. Mechanical diggers patterned after a low flat-bed type Irish potato harvester or harvester-windrower are often used. Care must be taken to bring enough soil up with the digging chain to minimize bruises. After the roots are harvested, they should be in the storage house for 6 to 8 days at 80°F to 85°F and a relative humidity of 85% to 90%. During curing, ventilation is required to remove carbon dioxide and replenish the oxygen level. Sweetpotato roots consume a significant amount of oxygen during curing while producing an equivalent amount of carbon dioxide. After curing, the temperature should be lowered to 57°F, but maintain a relative humidity of 85%. Do not wash sweetpotatoes before curing or storage. Curing promotes the healing (suberization) of cuts and bruises that occur during harvesting and handling. Curing also protects the roots from many storage diseases and excessive shrinkage while starches are being converted to sugars and other flavor components. Due to sweetpotato's tropical origin, roots will show chilling injury if held at a temperature below 54°F.

Sweetpotatoes are usually washed and graded, and sometimes waxed, before being shipped to market. Sweetpotatoes are graded into US Extra No 1, US No 1, US Commercial, US No 2 and Unclassified. All grades are based on the size, condition and absence of defects of the tubers being sent to market.

There are several insects that can cause damage to sweetpotato foliage and tubers. Since sweetpotato foliage grows vigorously, treatment for insect feeding is rarely necessary during the growing season. Insects feeding on sweetpotato tubers include: Whitefringed beetle larvae (grubs), Wireworms (larvae of click beetles), Flea beetle larvae and sweetpotato larvae – the most serious pest of sweetpotatoes.

There are several diseases of sweetpotatoes. Black Rot is caused by *Ceratocystis fimbriata* and can cause significant losses in storage, in transplant beds and in the field. This pathogen not only reduces marketable yield and quality, but also gives sweetpotatoes a bitter taste. Fusaruim Surface Rot and Fusarium Root Rot is caused by the fungus *Fusarium* which can persist in the soil for many years. Rhizopus Soft Rot is caused by the fungus *Rhizopus stolonifer* and mainly occurs after sweetpotatoe have been harvested and in storage. Java Black Rot is caused by the fungus *Diplodia gossypina* and is considered one of the most destructive diseases of sweetpotatoes in the Southern US. This disease is most frequently observed on sweetpotatoes in storage. Bacterial Soft Rot is caused by the pathogen *Erwinia chrysantbemi* and rotting of tubers can occur in the field as well as during shipment and storage. Charcoal Rot caused by the fungus *Macrophomina phaseoli* can cause losses of sweetpotatoes in storage, but serious losses seldom occur. This disease is sometimes confused with black rot and Java black rot. Scurf also known as soil-stain is caused by the fungus *Monilochaetes infuscans*. Damage from this disease is primarily superficial but still detracts from market value.

There are several herbicides that are labeled for weed control for beds producing slips as well as several herbicides labeled for weed control in field production. The use of raised beds with black plastic much and drip irrigation will minimize weed growth on the beds.

References:

Kemble, J. M., E. J. Sikora, D. Fields, M. G. Patterson and E. Vinson III. 2006. Guide to Commercial Sweetpotato Production in Alabama. Alabama A & M and Auburn University Cooperative Extension. 15 p.

Sanchez, e., T. Elkner, W. J. Lamont, Jr., K Demchak, B. K. Gugino, S. J. Fleischer, K. Watrous and L. LaBorde. 2017. Mid-Atlantic Commercial Vegetable Production Recommendations.

MANAGING PHYTOPHTHORA

John Esslinger, Penn State Extension Educator

Phytophthora *capsici* also called Phytophthora blight is the worse disease a vegetable grower may encounter. Phytophthora has the ability to ruin a crop quickly and totally. Over the past decade it has dramatically spread to "clean" farms. Phytophthora has the ability to last in the soil for seven or more years. It infects a wide range of vegetable crops but the crops most severely impacted have been pumpkins, winter squash, watermelon, and peppers.

How can this dreaded disease get onto your farm? It can happen in several ways. One grower got it after his fields were flooded. Another grower got it when he agreed to sell a couple of boxes of winter squash at the farmers' market for a friend. When the squash started to rot, he through the decaying fruit into one of his fields. The next summer he lost 5 acres of butternut squash in that field. Another grower borrowed a trans-planter from a neighbor that has phytophthora. One grower got it from a custom applicator's equipment. Several growers have gotten it from packing or repacking other peoples' produce on their farm.

How can you keep your farm clean? First, be aware of how phytophthora spreads. It moves with soil, equipment, feet, and water (both runoff and irrigation). Be sure that the water you use for irrigation is not contaminated. If a friend or neighbor has phytophthora, be very careful about sharing anything, walking in each other's fields, and avoid moving produce from their farm to yours. If you are buying produce, do not discard any unsold pieces on the farm. Divert any run-off from a neighboring farm that has phytophthora.

Second, do not create an environment which favors phytophthora. It thrives in low, wet areas and in compacted soil areas. Manage your irrigation so that your soils are moist but not saturated. This one is a tough one but – be careful how you use plastic mulch. Plastic allows heavy rainfall to gather between the rows. That is the same area that is compacted by field equipment. If you are using plastic or have low wet areas, consider subsoiling between the rows. It makes a big difference.

What can you do if you have phytophthora on the farm? Manage your crop rotations to avoid putting susceptible crops into phytophthora prone fields. Grasses are resistant to phytophthora capsici. Select phytophthora resistant varieties when available. They help but are not a silver bullet. Create an environment in which your plants will thrive: high organic matter, adequate moisture consistently, good fertility, good pest control, and good soil drainage.

Research conducted during the summer showed that fungicides significantly reduce the impact phytophthora on pepper fruit. The four treatments were Orondis Gold, Tanos and NuCop rotated with Revus, manure compost, and the check had no treatment. The Tanos and NuCop rotated with Revus and NuCop on a weekly basis gave the best control. It was also the most expensive treatment. Orondis Gold provided second best results. The Orondis was used as a drench at a 2.4 oz./acre rate which was the lowest labeled rate on the 2016 label. The current label has a lowest labeled rate of 4.8 oz./acre in order to get season long control. The manure compost showed a slight benefit on one of the pepper varieties used in the research but not on the other. There pepper variety that has genetic resistance was not significantly better than the susceptible variety. This may be explained by the fact that the resistant variety had large fruit and tended to bend under the weight of the fruit allowing some of the fruit to tough the soil.

Educational efforts have focused on keeping phytophthora off the farm and on cultural practices that minimize the impact of an infection. In 2016 a new fungicide was used with success in pepper fields on a Luzerne County farm. This farm has a long history of battling phytophthora. The fungicide, Orondis, appeared to stop the spread of a phytophthora infection despite weather conditions that favored the disease. Research was conducted in 2017 to determine if the apparent benefits of Orondis could be repeated, if there are other control options that offer equal or better control, and if control can be obtained at a lower cost per acre. One of the treatments was an application

John Esslinger is a Horticulture Extension Educator working for Penn State Extension. He has worked with farmers in his role as an Extension educator for 21 years. He previously worked as a Field Representative for Furmano Foods, Inc. John has a Masters in Horticulture Degree from Penn State University. He and his wife live in Bloomsburg, Pa. They have three children.

of manure based compost. The hope was that the biological activity stimulated by the compost would out-compete phytophthora in the soil.

The Pennsylvania Vegetable Growers Association and the Pennsylvania Vegetable Marketing and Research Program provided a grant that made the research possible.

The plot was planted on June 14, 2017 in Columbia County. A field in Benton, Pennsylvania was selected based on its history of phytophthora blight. Irrigation was available but due to adequate rainfall was not used until August 25, 2017.

A soil sample was taken and recommended lime was applied on May 26, 2017. Black plastic mulch on 6' centers was laid on June 12, 2017. Three randomized replications of each of the four treatments were established. The manure compost was worked into the soil in the compost treatment replications on May 22, 2017. The plot was planted on June 14, 2017. The peppers were planted in a double row 25' long. One of the double rows was planted to the cultivar Zsa Zsa and the other row was planted to the cultivar Playmaker. Zsa Zsa was selected because of its susceptibility to phytophthora and Playmaker was selected because of its resistance to phytophthora. The four replicated treatments were 1) Orondis 2) Revus & Nu-Cop HB rotated with Tanos & Nu-Cop HB, 3) manure compost, and 4) untreated check.

Treatment 1: Orondis Gold was applied one time only as a drench at the rate of 2.4 oz./acre on June 28, 2017. Label on the Orondis used in the research recommended is 2.4 oz. to 9.6 oz. per acre. Current Orondis labels recommend **4.8 oz.** to 9.6 oz. per acre.

Treatment 2: The Revus and Nu-Cop rotated with Tanos and Nu-Cop treatments were applied to the treatment 2 areas on a weekly rotating basis starting July 27 through September 12, 2017. Revus and Nu-Cop were applied in alternating weeks with the Tanos and Nu-Cop. Tanos was applied at 8 oz. /acre and Revus was applied at 8 oz. /acre (label recommendation) and the Nu-Cop was applied at 1 lb./acre. The Revus and Nu-Cop tank mix was applied on August 4, August 17, and September 1.

Treatment 3: The manure (dairy) compost was applied broadcast at the rate of 3 tons/acre on May 22, 2017. The compost was shallowly worked into the soil immediately after application.

Treatment 4: The check did not receive any fungicide or soil treatments.

The plot received 1.5 tons of high calcium lime based on soil test recommendations. The plot was fertilized with 80-80-80 on June 1, 2017. The plastic mulch was laid on June 11, 2017.

Phytophthora was not observed in the plot from the time of planting though the middle of August, so the plot was irrigated on August 25th and inoculated with phytophthora on August 28th. Phytophthora was first observed on Zsa Zsa fruit in the untreated check on September 15, 2017. On September 21, 2017 each plant was evaluated for the presence of phytophthora.

Results: The table below indicates the number of plants that had at least one fruit with phytophthora symptoms out of the 75 plants that made up each treatment.

Treatments:	Zsa Zsa	Playmaker
Orondis	13 b	22 b
Tanos & Copper, Revus & Copper	2 a	1 a
Manure compost	35 c	25 b
Untreated check	24 c	38 c

The Tanos & Copper, Revus & Copper treatment out-performed the other treatments. The Orondis treatment was second best. The manure compost had less disease than the untreated check with the Playmaker variety but not with the Zsa Zsa treatment.

Below is the cost comparison of the treatments:

Treatment 1 consisted of Orondis applied at 2.4 oz./acre which cost **$65.00/acre**.

Treatment 2 consisted of Tanos & Nu-Cop (July 27, Aug. 8, Aug. 25 and Sept. 12) rotated with Revus & Nu-Cop (Aug. 4, Aug. 17, Sept. 1) applied as tank mixes and sprayed over the top. Tanos was applied at the rate of 8.0 oz./acre, Revus was applied at 8.0 oz./acre, and Nu-Cop was applied at 1 lb./acre.

Tanos cost per/acre $19.33 X 4 applications = $77.32/acre

Revus cost per/acre $21.64 X 3 applications = $64.92/acre

Copper cost per/acre $6.00 X 7 applications = $42.00/acre

Total cost of treatment 2 per acre was **$184.24**. (does not include the cost of 7 applications)

Treatment 3 consisted of 3 tons of manure compost/acre which cost approximately **$180.00/acre**.

Treatment 4 had no additional costs.

Conclusions: Treatment 2 performed very well. While the treatment did not totally prevent disease development, it did keep disease to a manageable level. The cost was relatively high. Treatment 1 did a good job but there was enough diseased fruit to cause concern. Since Orondis was only applied once and at the lowest labeled rate the cost per acre was significantly lower than the other treatments. Syngenta has increased the lowest labeled rate from 2.4 oz./acre to 4.8 oz./acre. The 4.8 ounce rate gives better season-long control and would still be the lowest cost treatment. The treatment 3 compost had little or no benefit in managing the disease. The treatment cost was high compared to the fungicidal benefit. There was not a significant difference in susceptibility of the Zsa Zsa and the Playmaker. This may be explained by the fact that since the playmaker is a large fruited bell pepper. Due to the weight of the fruit (no harvesting was done) the plants tended to lean over allowing the fruit to come in contact with the soil. The Zsa Zsa is a smaller fruited pepper that tended to hold the fruit up off the soil

KEEPING PA VEGETABLE GROWERS PROFITABLE: STATEWIDE CULTIVAR TRIALS

Elsa Sánchez, Associate Professor of Horticultural Systems Management
Tim Elkner, Senior Extension Educator, Horticulture
Tom Butzler, Senior Extension Educator, Horticulture
Bob Pollock, Extension Educator, Horticulture
Bill Lamont, Professor of Vegetable Crops
The Pennsylvania State University Department of Plant Science and Extension

Selecting which cultivar to grow is critical to successful commercial production. When a cultivar suited to an area and having high yield and quality for market is grown, growers can make a profit. In 2016 we evaluated 15-25 lb orange, smooth-faced pumpkins. Pumpkins are an important crop for diversified vegetable operations in Pennsylvania. They are grown on 1,330 of Pennsylvania's 3,968 vegetable farms, ranking 1st in number of farms the US (2012 Census of Agriculture).

The study was conducted in southwestern Pennsylvania at Yarnick's Farm, LLC in Indiana, in central Pennsylvania at Pennsylvania State University's Russell E. Larson Research Center in Pennsylvania Furnace and, in southeastern Pennsylvania State University's Southeast Research and Extension Center in Manheim.

Twenty-one pumpkin cultivars (see Table 1 below) were evaluated in a conventional system in 2016-17. All seed was treated with Farmore except 'Camaro' seed which was untreated.

At all sites, pumpkins were direct seeded. At the southwestern site rows were spaced 6 feet apart with 3 feet between plants and at the central and southeastern site row were spaced 8 feet apart with 4 feet between plants in a row. Four plots of each cultivar were planted with each plot consisting of 6 plants. Data were collected from all 6 plants.

Pests were managed following recommendations in the 2016 Commercial Vegetable Production Recommendation guide.

The standard used was 'Gladiator' based on conversations with growers.

Elsa Sánchez is an Associate Professor of Horticulture in the Department of Plant Science at Penn State University. Her responsibilities are 60% extension and 40% undergraduate teaching. Current extension projects focus on sustainable and organic production of vegetable crops. She earned a BS in Horticulture and a MS in Agricultural Biology at New Mexico State University and a PhD in Horticulture at Washington State University. Elsa and her husband, Chris, live in State College, PA with their daughters Laurel and Lilly

Table 1. Cultivars, seed sources, maturity date of cultivars evaluated in 2016-17.

Cultivar	Source	Maturity[z]
Ares	Harris Moran Seed Co., Davis, CA	115
Bayhorse Gold	Rupp Seeds Inc., Wauseon, OH	100
Camaro	Hollar Seeds, Rocky Ford, CO	110
Cargo	Johnny's Selected Seeds, Winslow, ME	100
Challenger	Hollar Seeds, Rocky Ford, CO	100
Eagle City Gold	Rupp Seeds Inc., Wauseon, OH	100
Earlipak	Sakata Seed America, Morgan Hill, CA	95
Early King	Abbot & Cobb	90
Gladiator	Harris Moran Seed Co., Davis, CA	115
Gold Challenge	Rupp Seeds Inc., Wauseon, OH	105
Hannibal	Hybrid Seed Co., Feastervillle, PA	105
Honky Tonk	Sakata Seed America, Morgan Hill, CA	105
Kratos	Harris Moran Seed Co., Davis, CA	100
Magic Lantern		110
Magic Wand		115
Mr. Wrinkles	Sakata Seed America, Morgan Hill, CA	100
Orange Rave	Rupp Seeds Inc., Wauseon, OH	105
Rhea	Harris Moran Seed Co., Davis, CA	105
Solid Gold	Rupp Seeds Inc., Wauseon, OH	100
Spartan	Sakata Seed America, Morgan Hill, CA	100
Zeus	Harris Moran Seed Co., Davis, CA	110

[z]Based on seed catalogs.

At the southwestern site a raised bed system without plastic mulch was used. When beds were pulled, 600 lb/acre of 13-13-13 was applied through the bedmaker. Direct seeding occurred on June 25, 2016 and June 20, 2017. A single line of drip tape was installed over each bed to use only in the event the crop needed to be saved as there wasn't a pond at this site. In 2016, irrigation was used to get the crop started. Pre-emergent herbicide was applied.

Pumpkins were harvested on October 8, 2016 and October 10 and 13, 2017 and were categorized as fully orange, turning orange, mature green and unmarketable. Quality of the handles was also determined at this site.

At the central site, potash, and phosphate were applied based on soil test recommendations. Additionally, 50 lb/acre nitrogen was broadcast preplant on 23 May 2016 and 12 June 2017. An additional 25 lb/acre nitrogen was fertigated throughout the growing season. At this site a plasticulture system using a single line of drip tape (T-Tape model 508-12-450; John Deere, Moline, IL) placed on the center of the bed and black embossed plastic mulch (Sigma Plastic Groups, Allentown, PA) was used. Beds were pulled and plastic and drip tape were installed on June 10, 2016 and June 12, 2017. Plants were provided with 1-1.5 acre-inches of water each week through drip irrigation. Herbicide was also applied on June 10, 2016 and June 13, 2017. Planting holes were punched and direct seeding occurred on June 13, 2016 and June 22, 2017.

Pumpkins were harvested on September 16 and 20, 2016 and cut on September 29 and harvested on October 5, 2017. Pumpkins were counted and weighed in these categories: fully orange, turning orange or mature green (full sized and dark green) and unmarketable. Immature green fruit were left in the field.

At the southeastern site pumpkin seed were direct seeded in a no-till system into rye residue on June 7, 2016 and June 8, 2017. A single line of drip tape tape (T-Tape model 508-12-450; John Deere, Moline, IL) was placed in the center of each row. Plants were provided with 1-1.5 acre-inches of water each week through drip irrigation. Based on soil test recommendations, phosphate, and potash were not applied. Nitrogen was applied at a rate of 90 lb/acre with 50 lbs broadcast preplant and the remainder fertigated throughout the growing season.

Timothy Elkner is a regional horticulture educator based in Lancaster County, PA. His prime areas of responsibility are commercial vegetable and fruit production. He conducts applied research on vegetables and small fruit with an emphasis of variety evaluations. He has a B.S. degree in Agricultural Sciences from Cook College (Rutgers University) and an M.S. and Ph.D. in Horticulture from Clemson University and Virginia Tech, respectively

Pumpkins were harvested on October 14, 2016 and October 11 and 16, 2017. At this site harvest occurred when all fruit was fully orange (no fruit was turning orange). Quality of the handles (stems) was rated at this site using a 1-5 scale with 5 indicating the highest quality.

Data were pooled by site and year and analyzed using the GLIMMIX. Means were separated at the 5% level using the slice option to perform Tukey's multiple comparison test.

Results

Significant interactions between year, site, and cultivar were observed for many variables as indicated in Table 2 below.

Table 2. Statistical interactions between site, year, and cultivar for 21 cultivars of pumpkin grown in 2016-17 in three locations in Pennsylvania. '*" indicates interaction significant at the 5% level, 'NS' indicates the interaction was not significant.

	Marketable yield (lb)	Marketable yield (no.)	Unmarketable yield (no.)
Site x year	*	*	*
Site x cultivar	*	*	NS
Year x cultivar	NS	*	*
Site x year x cultivar	NS	*	NS

Southwestern Site

Yields in 2016 were lower at this site because of stress early in the growing season. Planting was delayed due to very dry conditions, then dry weather post emergence through the 3rd week of July resulted in slow and uneven germination and growth. In 2017, extended wet weather created favorable conditions for phytophthora blight which limited yields.

Mean weight of marketable pumpkins for all cultivars was not different from 'Gladiator' or each other in both years (Table 3).

Mean number of marketable pumpkins for all cultivars was not different from 'Gladiator' or each other in both years.

Mean number of unmarketable pumpkins for all cultivars was not different from 'Gladiator' or each other in both years (Table 4).

Central Site

'Challenger' produced a higher mean weight of marketable pumpkins than 'Gladiator' in 2016. 'Early King' and 'Camaro' produced a higher mean weight than 'Gladiator' in 2017. Marketable pumpkin weight was not different for any other cultivar in either year compared to 'Gladiator'. In 2016, 'Challenger' produced higher mean pumpkin weight than 'Eagle City Gold', 'Gold Challenger', 'Gladiator', 'Mrs. Wrinkles', and 'Zeus'. No other differences between cultivars were observed. In 2017, 'Early King' produced higher mean pumpkin weight than 'Gold Challenger', 'Hannibal', 'Gladiator' and 'Zeus'. Additionally, 'Camaro' produced higher mean pumpkin weight than 'Gladiator' and 'Zeus'. No other differences between cultivars were observed.

Mean number of marketable pumpkins from 'Gladiator' plants was not different than any other cultivar in both years. In 2016, 'Honky Tonk' produced more marketable pumpkins than 'Gold Challenger' and 'Cargo'. Additionally, 'Camaro' outperformed 'Cargo' in marketable number of fruit in 2017.

Mean number of unmarketable pumpkins for all cultivars was not different from 'Gladiator' in both years.

Tom Butzler has been the Horticulture Educator for Penn State Cooperative Extension in Clinton County, Pennsylvania since 2000. Tom earned his Master of Science degree in Plant Pathology at North Carolina State University and a Bachelor of Science degree in Horticulture from The Pennsylvania State University. Prior to his appointment with Penn State, he was an extension educator in commercial horticulture with North Carolina Cooperative Extension

Southeastern Site

Mean weight of marketable pumpkins for all cultivars was not different from 'Gladiator' in both years (Table 3). In 2016, 'Challenger' marketable weight was higher than 'Eagle City Gold'. In 2017, 'Kratos' marketable weight was higher than 'Hannibal' and 'Gold Challenger'. All other cultivars were not different from each other.

In 2016, the mean number of marketable pumpkins was not different from any cultivar. In 2017, mean number was not different from 'Gladiator' for any cultivar. In this year, 'Kratos' yielded more pumpkins than 'Gold Challenger'. All other cultivars were not different from each other.

Mean number of unmarketable pumpkins for all cultivars was not different from 'Gladiator' or each other in both years.

Based on yield, all cultivars evaluated were not different than the standard 'Gladiator'. Growers should consider quality including shade of orange, shape, and degree of ribbing when selecting cultivars. Many cultivars can be selected to meet varying consumer preference for these quality factors without sacrificing yield.

Bob Pollock is a Penn State Extension Educator with 32 years' experience conducting educational programs in Horticulture, IPM, pesticide safety and 4-H for commercial and non-commercial audiences. He earned a B.S. in Horticulture in 1981 from Penn State. Bob is based in Indiana County and serves on the Extension Tree Fruit, Vegetable, and Green Industry teams. Bob and his wife Annette have two grown sons and reside in Indiana, PA.

Table 3. Marketable yield of 21 pumpkin cultivars grown at three locations in Pennsylvania in 2016-17.

Cultivar	Marketable Yield (lb)						Marketable Yield (no.)					
	Southwestern Site		Central Site		Southeastern Site		Southwestern Site		Central Site		Southeastern Site	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Ares	34 a[z]	27 a	294 ab	285 abc	192 ab	257 ab	1.5 a	1.3 a	16.3 ab	11.0 ab	12.0 a	11 ab
Bayhorse Gold	58 a	57 a	223 ab	279 abc	164 ab	240 ab	2.8 a	2.8 a	13.3 ab	13.0 ab	12.5 a	11.3 ab
Camaro	41 a	77 a	310 ab	354 ab	152 ab	236 ab	1.8 a	5.3 a	13.3 ab	16.9 a	10.8 a	10.0 ab
Cargo	31 a	39 a	236 ab	230 abc	196 ab	208 ab	1.8 a	1.8 a	11.8 b	8.0 b	11.0 a	8.0 ab
Challenger	54 a	95 a	355 a	323 abc	286 a	247 ab	1.5 a	2.8 a	17.0 ab	10.5 ab	15.5 a	9.3 ab
Eagle City Gold	68 a	47 a	207 b	318 abc	131 b	269 ab	3.5 a	2.5 a	13.5 ab	15.3 ab	10.5 a	12.0 ab
Earlipak	23 a	15 a	234 ab	252 abc	174 ab	229 ab	1.0 a	1.0 a	13.3 ab	9.7 ab	10.3 a	8.5 ab
Early King	49 a	7 a	323 ab	366 a	247 ab	244 ab	1.8 a	0.5 a	15.0 ab	13.0 ab	14.8 a	9.0 ab
Gladiator	27 a	4 a	201 b	197 c	152 ab	233 ab	1.0 a	0.3 a	15 ab	9.5 ab	11.8 a	12.0 ab
Gold Challenger	33 a	28 a	210 b	221 bc	163 ab	139 b	1.5 a	2.0 a	11.5 b	11.0 ab	10.0 a	6.8 b
Hannibal	51 a	69 a	216 ab	200 bc	165 ab	175 b	2.0 a	3.3 a	13 ab	10.5 ab	10.3 a	8.3 ab
Honky Tonk	43 a	24 a	248 ab	250 abc	169 ab	209 ab	2.3 a	1.5 a	20.0 a	12.3 ab	13.8 a	11.3 ab
Kratos	58 a	48 a	277 ab	310 abc	196 ab	326 a	1.8 a	2.5 a	17.0 ab	12.8 ab	12.8 a	14.8 a
Magic Lantern	59 a	11 a	224 ab	282 abc	167 ab	182 ab	2.5 a	1.0 a	18 ab	14.5 ab	15.3 a	9.8 ab
Magic Wand	62 a	11 a	232 ab	235 abc	169 ab	218 ab	2.5 a	0.8 a	18.0 ab	11.5 ab	13.0 a	11.5 ab
Mrs. Wrinkles	83 a	0 a	183 b	267 abc	187 ab	191 ab	5.3 a	0.0 a	12.5 ab	12.3 ab	14.5 a	10.0 ab
Orange Rave	71 a	25 a	255 ab	268 abc	173 ab	224 ab	3.8 a	1.5 a	17.5 ab	12.8 ab	12.0 a	12 ab
Rhea	62 a	30 a	250 ab	261 abc	145 ab	259 ab	2.0 a	1.5 a	17.3 ab	9.8 ab	10.0 a	11.5 ab
Solid Gold	56 a	43 a	254 ab	275 abc	193 ab	230 ab	2.3 a	2.5 a	13.0 ab	10.8 ab	10.8 a	9.5 ab
Spartan	33 a	27 a	225 ab	286 abc	219 ab	225 ab	1.5 a	1.5 a	14.8 ab	10.5 ab	15.0 a	10.5 ab
Zeus	26 a	14 a	165 b	193 c	171 ab	205 ab	1.0 a	0.8 a	13 ab	11.0 ab	14.8 a	10.8 ab

[z]Values are the mean of 4 replications; data were analyzed using GLIMMIX and means were separated at the 5% level using the slice option to perform Tukey's multiple comparison test; values followed by different letters within a column are significantly different.

Dr. William J. Lamont Jr. is a Professor and Extension Vegetable Crops Specialist in the Department of Plant Science at Penn State University. He was born and raised in rural Pennsylvania and obtained two undergraduate degrees, one in Economics and Business from Lebanon Valley College and one in Horticulture from Delaware Valley College. He earned his M.S. and Ph.D. degrees from Cornell University. Dr. Lamont has an extensive background in research, extension and teaching. In his current extension position Dr. Lamont is responsible for the culture and management of vegetable crops. He has worked at North Carolina State University and Kansas State University prior to coming to Penn State in 1997. He and his wife Phyllis reside on 28 acres of land between Pine Grove Mills and McAlevy's Fort, PA

Table 2. Unmarketable yield of 21 cultivars of pumpkins grown in three locations in Pennsylvania in 2016-17.

Cultivar	Unmarketable Yield (no.)					
	Southwestern Site		Central Site		Southeastern Site	
	2016	2017	2016	2017	2016	2017
Ares	0.0[z]	1.5	0.0	0.3	0.8	1.8
Bayhorse Gold	0.0	1.5	0.5	0.0	2.0	1.8
Camaro	0.3	2.0	0.0	0.0	3.3	1.8
Cargo	0.0	2.3	0.0	0.0	0.8	2.3
Challenger	0.0	2.25	0.0	0.3	2.5	1.8
Eagle City Gold	0.0	2.5	0.0	0.0	1.3	1.0
Earlipak	0.0	3.3	0.0	0.0	1.0	2.0
Early King	0.3	2.0	0.3	0.3	1.0	1.5
Gold Challenger	0.0	1.3	0.5	0.0	1.8	2.8
Gladiator	0.0	2.5	0.5	0.3	1.0	2.3
Hannibal	0.0	2.3	0.0	0.3	2.8	3.3
Honky Tonk	0.0	3.3	0.0	0.3	0.5	2.3
Kratos	0.3	2.0	0.0	0.0	0.3	3.3
Magic Lantern	0.0	3.8	0.3	0.5	0.8	1.5
Magic Wand	0.0	3.3	0.0	0.0	1.0	3.5
Mrs. Wrinkles	0.3	0.5	1.0	0.5	1.3	2.0
Orange Rave	0.0	1.0	0.3	0.0	2.0	1.3
Rhea	0.3	1.5	0.5	0.3	1.0	2.8
Solid Gold	0.3	1.8	0.3	0.5	1.3	1.8
Spartan	0.0	1.0	0.0	0.3	0.8	2.8
Zeus	0.0	3.8	0.3	0.8	1.5	2.0

[z]Values are the mean of 4 replications; data were analyzed using GLIMMIX and means were separated at the 5% level using the slice option to perform Tukey's multiple comparison test; values followed by different letters within a column are significantly different.

SQUASH BEES OF PENNSYLVANIA

Margarita Lopez-Uribe, Penn State Univ.

Bees improve the quality and quality of fruits of the crops they visit, and their role as pollination agents has been estimated to be worth at least 30 billion dollars per year to the US's economy. Squash bees are specialist pollinators of plants in the genus Cucurbita, a genus that includes high-valued crops such as pumpkins, squash, zucchini and other gourds, which are valued at $15M/year in Pennsylvania. Squash bees are so specialized on Cucurbita plants that they exclusively rely on the pollen collected from flowers of this one plant genus to feed their brood (eggs and larvae), and are the most important and effective pollinator of this crop. Even though squash bees are considered native pollinators in northeastern US, they are recent invaders that have followed the domestication and cultivation of squash and pumpkin throughout North America. In this talk, I will present details about the biology and history of the squash bees, and I will provide valuable information that may help enhance populations of these wild pollinators in pumpkin farms.

Margarita received her BS in Biology from Universidad de los Andes (Colombia), her MS in Genetics and Evolution from Universidade Federal de São Carlos (Brazil), and her PhD in Entomology from Cornell University (USA). She is broadly interested in understanding how environmental change and life-history traits affect demography, health and long-term persistence of bee pollinator populations.

WHY ARE MY CUCURBITS COLLAPSING?

Beth K. Gugino
Department of Plant Pathology and Environmental Microbiology,
The Pennsylvania State University
204 Buckhout Lab, University Park, PA 16802
bkgugino@psu.edu

There are a number of soilborne pathogens and insect vectored bacterial diseases such as bacterial wilt and cucurbit yellow vine decline as well as abiotic stresses including water logged soils that can cause cucurbits to wilt. Below are descriptions of a few soilborne diseases that can lead to wilting of more mature cucurbits. In the first case, a root and crown rot leads to plant collapse. In the next two cases, the wilting results from the pathogen colonizing the vascular system and preventing the plant from moving water and nutrients from the roots to the shoots. In the fourth case, crown and petiole lesions as well as root rot lead to partial or total collapse of the vine. Although there not much that can be done once you see symptoms in the field, it is important to determine the cause to inform your management decisions for next growing season whether it be changes in your crop rotation, selection of resistant cultivars, etc. It can often be difficult to distinguish these diseases in the field so consider submitting a whole plant sample to the Penn State Plant Disease Clinic for diagnosis. As you read below, recognize that the biology and epidemiology of these pathogens often limit available management tactics. One common theme however is improved soil health. Improving soil health can facilitate better soil drainage, soil tilth and microbial activity; all of which promote plant health and reduce plant stress.

Fusarium Crown and Root Rot

Although all cucurbit crops are susceptible at all ages, pumpkins and squash (*Cucurbita pepo*) are especially susceptible. Fusarium crown and root rot is caused by *Fusarium solani* f. sp. *cucurbitae* which is a different pathogen than the one that causes Fusarium wilt (described below). Usually, the first symptoms observed are a yellowing and wilting of the leaves which develop as a result of a rotting of the roots. The root rot starts as a water soaked area found at the base of the crown and upper portions of the taproot. It is not uncommon for infected portions of the roots can develop pinkish color. This soilborne fungal pathogen can also develop as a fruit rot on fruit that are either wounded or come in contact with the soil at the soil surface. The sunken round to oblong, tan to brown lesions will remain firm unless colonized by secondary decay organisms. This disease is exacerbated by high soil moisture levels.

Above ground yellowing and wilting symptoms resulting from a below ground root rot caused by Fusarium on pumpkin. The pinkish roots characteristic of Fusarium can be seed in the lower right.

The pathogen can be both soilborne and seedborne. It can survive in the soil two to three years so at least a four-year rotation out of cucurbits is recommended. Seed treatments containing Thiram can help to reduce transmission from the seed to the young seedling. In-season management options are limited. Applications of Proline (propiconazole; PHI 7 days) may reduce symptoms if used early in the season.

Beth K. Gugino is an Associate Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University located at University Park, PA. Her extension and research program focuses on the identification, epidemiology and management of vegetable diseases important to the Pennsylvania and the Northeast region. She received her B.S. in Horticulture and M.S. and Ph.D. in Plant Pathology from The Pennsylvania State University. She was a post-doc at the New York State Agricultural Experiment Station with Cornell University working with diseases of vegetable crops and soil health for four years before returning to Penn State in June 2008.

Fusarium Wilt

Fusarium wilt most commonly affects watermelon, muskmelon and cucumber. The fungal pathogen *Fusarium oxysporum* is very host specific so watermelon, muskmelon and cucumber are all susceptible to their own unique strain of the pathogen. For example, *Fusarium oxysporum* f. sp. *niveum* (FON) only infects watermelon. In addition, there are distinct races, which are important to consider when selecting resistant cultivars so for example, FON can be further broken down into races 0, 1, 2, or 3.

Fusarium wilt of watermelon. Photo: Nathan Miller, NCSU.

On older plants, the leaves will initially become a dull green to gray-green color and then yellow. The shoot tips will wilt become brown and dried up with individual vines on the plant collapsing and eventual collapse of the plant. Symptoms are most severe when plants are stressed or during fruiting. Optimal conditions for disease development are when soil moisture is low and soil temperatures are 77 to 81°F. One diagnostic characteristic is the light to dark brown discoloration of the xylem tissue in the crown and lower portion of the stem. This pathogen can persist as chlamydospores in the soil for many years (in some cases 15 to 20 yrs). Since Fusarium is a true soilborne pathogen, the symptoms will develop in hot spots with diseased plants interspersed between healthy ones. Unlike foliar diseases such as powdery mildew that produce a large number of spores that spread the disease within and between fields, the Fusarium wilt pathogens are considered monocyclic. This means that it does not spread from plant to plant during the season although the variability in symptom development can give this impression. So management practices implemented this year will impact disease pressure in future years.

Management requires an integrated approach that first focuses on exclusion through the selection of pathogen-free transplants. Long-term crop rotations of 5 to 7 years are necessary to reduce the pathogen population in infested fields. In some field situations, short rotations with resistant cultivars have shifted the dominant pathogen race to one which there may or may not be resistant cultivars available. For this reason it is important to accurately diagnose Fusarium wilt and know which cultivar developed symptoms. Information about Fusarium wilt resistance on recommended muskmelon and watermelon cultivars adapted for our region can be found in the 2018 Mid-Atlantic Commercial Vegetable Production Recommendations. Grafting may be another approach to disease management. This technique, although expensive and labor intensive, has been used extensively other cucurbit producing regions of the world for managing Fusarium wilt especially on watermelon. Extensive research trials conducted by K.L. Everts and X.G. Zhou at the University of Maryland has also demonstrated that the use of hairy vetch as a cover crop in combination with resistant cultivars can reduce Fusarium wilt of watermelon.

Verticillium Wilt

Verticillium wilt, caused by *Verticillium dahliae*, tends to be most problematic on cucumber and pumpkin within the cucurbit crop family however, all cucurbits can be affected. Unfortunately, the pathogen has an extensive host range including over 400 different hosts, many of which are vegetables such as eggplant, potato, pepper, and strawberries grown in rotation with cucurbits. The characteristic symptoms typically develop during fruit set with the lower leaves initially becoming off green and some leaves developing yellow, V-shaped lesions at the leaf margin. Wilting occurs during warm dry periods when the plant is under stress however, pathogen grows within the plant tissue when soil temperatures are relatively cool (70 to 75°F). As the disease develops the leaves eventually become necrotic and dry up and the xylem tissue in the crow becomes tan to brown. With Verticillium wilt, it is common to see the symptoms on only one side of the plant. The pathogen can survive in the soil as long as 8 to 10 years, as microsclerotia that are the size of poppy seeds. Similar to Fusarium wilt, the pathogen is monocyclic so there tends not be multiple rounds of pathogen infection occurring during the season.

A multifaceted preventative approach is necessary for managing Verticillium wilt. Once the plants are infected, rogueing the symptomatic plant to break the development of microsclerotia is the primary management tool. Good rotational crops for cucurbits include beans, carrot, celery, lettuce and peas which are considered non-hosts. Inclusion of grain crops in the rotation would be another option. There are also a number of resistant or tolerant cultivars of tomato and potato available. Typically these are denoted with the letter 'V' in the seed catalogues. Since the microsclerotia are easily disseminated though the movement of soil, efforts to reduce the movement of soil between fields and farms on equipment is also important.

Phytophthora Blight and Fruit Rot

Depending on the plant growth stage, *Phytophthora capsici* causes a wide array of symptoms ranging from seedling damping-off, leaf spots, foliar blight, root and crown rot, stem lesions to fruit rot on numerous vegetables including pepper, tomato, eggplant and most types of cucurbits. Symptoms usually develop first in low areas of the field where the soil remains wet longer. On the vines, lesions are initially water soaked before becoming dark olive green and then dark brown. Lesions that girdle the stems result in a rapid collapse of the plant part above the lesion. Similar lesions can also develop on the petioles and the leaves and result in rapid death of the plant part. Initial symptoms on the fruit are water soaked or depressed spots typically on the underside of the fruit where it is in contact with the soil. Symptoms can develop on the upper side of the fruit following rain or an irrigation event that splashes infested soil and spores up onto the fruit. Eventually the fruit will become covered with white sporangia and will rapidly collapse either in the field or shortly after harvest. The sporangia and the zoospores that cause new infections are released when the soil is saturated which is why this disease is most prevalent poorly drained soil and/or after significant rainfall.

Similar to Fusarium and Verticillium, *Phytophthora capsici* produces an overwinter survival structure (oospore) that enable the pathogen to survive between susceptible crops and seasons. The mycelium of the pathogen can also survive associated with the crop residue. The oospores germinate to produce sporangia which can either germinate directly or produce numerous zoospores that move readily though the soil under wet conditions.

Exclusion is the most effective management tool for fields that do not have a history of Phytophthora blight. The pathogen is easily spread through the movement of water within and between fields or in the soil on equipment and boots. Manage soil moisture by not planting in poorly drained soils or low lying areas, sub-soiling to break-up hard pans, raised beds and avoiding excessive irrigation. Avoid irrigating from ponds or surface water sources that may contain water that drained from infested fields. Minimize splash dispersal of spores and surface water movement between rows or fields. In fields where Phytophthora is a problem minimize movement of people and equipment from infested to uninfested fields. Remove diseased plants and fruit from the field. This will reduce the spread of secondary inoculum. If sections of the field are very bad, consider disking these areas under to reduce pathogen inoculum and further spread in the field. Avoid culling infected fruit into production fields.

Under favorable conditions, fungicides will only suppress Phytophthora blight at best. Several including mefenoxam are registered for application through the drip for suppression of the root and crown rot phase early in the season. Foliar applications of oomycete specific fungicides such as Orondis Ultra, Ranman, Revus, Presidio, Zampro, Forum and Tanos when initiated prior to symptoms development will also offer some suppression however, when environmental conditions are favorable it can be very difficult manage. See the 2018 Mid-Atlantic Commercial Vegetable Production Recommendations for a listing of specific products and rates.

Summary

In addition to the disease specific management recommendations discussed above, efforts to improve overall soil health will contribute to improved disease management either by directly impacting the pathogen population in the soil and/or improving overall plant health. Increasing soil organic matter will also support the soil microbial populations which in turn help suppress these pathogens and help contribute to the overall health of the agroecosystem. A healthy soil is also able to resist degradation and will be more resilient when unfavorable conditions occur.

MANAGING CUCUMBER BEETLES WHILE CONSERVING POLLINATORS

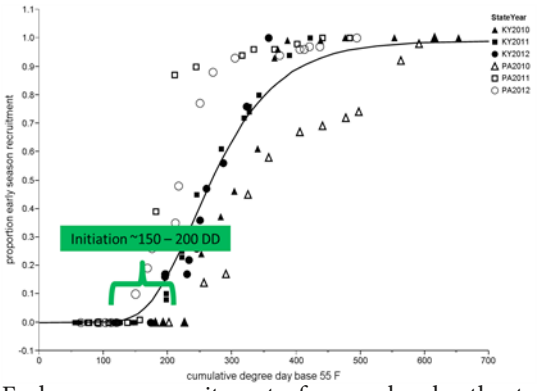
Shelby J. Fleischer, Departments of Entomology
The Pennsylvania State University, University Park, PA 16802

Cucumber beetles cause direct feeding damage to above and below ground portions of the cucurbits, and transmit the bacterial pathogen *Erwinia tracheiphila* which cause bacterial wilt. Most farms growing cucurbits require insecticides to manage these pests, but minimizing insecticides will help conserve pollinators. Understanding some biological interactions can help manage the pest complex while minimizing harm to pollinators.

Crop-Insect-Pathogen Interactions. Cucumber beetles develop well on plants in the *Cucumis* (cantaloupe, cucumber) and *Cucurbita* (squash, pumpkin) genus, but not the *Citrullus* (watermelon) genus. And these beetles are specialists – they require cucurbit hosts to survive. So the first management approach is sanitation: create a host free period. Farms that have a succession of cucurbits tend to have higher pest pressure. Landscapes with cucumbers, melons, and summer squash, followed by pumpkins that continue to frost, provide a continuous resource for the beetles to thrive.

There are crop-specific interactions between the pathogen, the crop, and crop growth stage. As with the beetles, the pathogen develops well on plants in the *Cucumis* (cantaloupe, cucumber) and *Cucurbita* (squash, pumpkin) genus, but not the *Citrullus* (watermelon) genus. Recent reports recognize two pathogen strains, and the speed at which they cause disease maps to their host (strains from *Cucumis* cause more rapid wilt on *Cucumis* plants, strains from *Cucurbita* cause more rapid wild on *Cucurbita* plants). We have both in PA. The genome was recently defined, and future work could help develop host plant resistance. However, there is some degree of tolerance: the severity of disease symptoms expressed after inoculation decreases as the plant matures. This is important for management – protecting younger plants is the priority. But this also varies with the crop: Although young pumpkin fields can be lost due to heavy beetle pressure, if pumpkins are protected during early growth stages, this goes a long way. We tend not to see significant disease problems if beetles inoculate plants late in pumpkin crop development: isolated plants may show disease, but it does not spread throughout a field. In contrast, cucumbers, and to a lesser extent cantaloupes, are more sensitive throughout crop development. Also, another insect-plant-pathogen interaction is going on. Plant volatiles help beetles find cucurbits, but the pathogen influences this. Some cucurbits actually change their 'smell' when infected by the pathogen. Wilting leaf tissue attracts beetles, increasing pathogen acquisition by more beetles. Later, they move more to healthy flowers. This helps the pathogen move from infected to healthy plants.

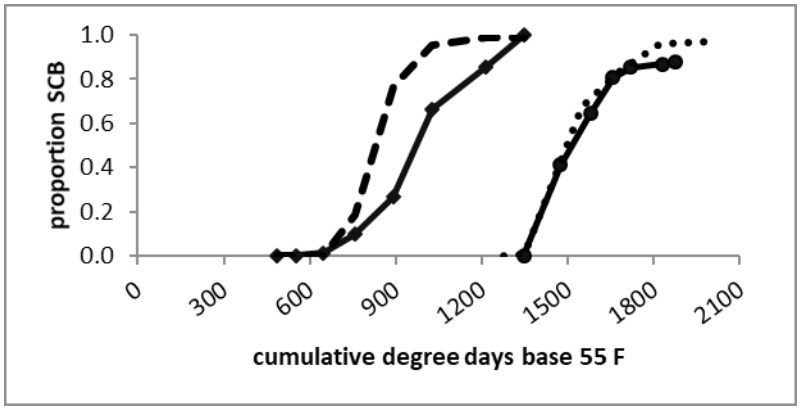
Phenology means the timing of biological events. Information about when to expect these adults to immigrate into your fields, when the immature stages will develop into the next generation of adults, and how many generations to expect, can help with management. We used flats of transplants as insect traps, checking them daily for immigration. Males are the first to arrive. A combination of a male-produced aggregation pheromone, volatiles from plants that have feeding damage, and frass from the beetles, rapidly attract additional overwintered adults. The cumulative numbers of immigrants can be graphed as an S-shaped curve. The time of 150-200 degree-days, base 55 F, provided a good fit for when this overwintered adults are active. There are management implications for this type of immigration. It is not uncommon to see variation in beetle density among groups of fields in a farmscape, or among plants started at different planting dates. The earliest-planted fields often show the first influx of beetles. If the beetles are well-controlled in these early plantings, late-planted fields may see lower pest pressure, or a slower immigration process. Similarly, transplants set out early, and surrounding a field, can be used as a trap crop. This strategy is called "Perimeter-Trap-Crop" or PTC. PTC with highly attractive, larger cucur-



Early season recruitment of cucumber beetles to trap flats. Data from 2 states, 3 years.

Dr. Fleischer is on the faculty of the Department of Entomology at The Pennsylvania State University where he specializes in population dynamics of insects. He has been worked in vegetable agroecosystems for over 20 years. He previously was a Research Scientist at Virgina Tech and Research Associate at Auburn University. He received his B.S. in Biology from St. Mary's College of Maryland, his M.S. in Entomology from Virgina Tech and his Ph.D. in Entomology from Auburn. A native of Washington, D.C., he and his wife Barbara have two daughters and three grandchildren.

bits, such as various gourd species, can serve as a trap crop if you kill the beetles on the trap, reducing the pest pressure on the later-planted crops in the rest of the field. We also tracked the time of arrival in small field plots, assumed that egg-laying started when adults first arrived, and compared our degree-day modeled estimate of when to expect the next generation to the field-measured observations. The models fit reasonably well in 3 of 5 datasets. This suggests that we can provide advance warning of when to expect emergence of 2nd and 3rd generation adults. Often, these emergences of adults results in a strong increase in pest density. Knowing when this is expected to occur can help time management efforts for that field and for neighboring fields which is where some of these new adults will disperse to.



Observed (solid) and modeled (dotted) line of the proportion of beetle density for 1st and 2nd generation. Example from 2011.

Biocontrol: We have determined that a bacterial biological control agent, *Pseudomonas fluorescens (Pf)*, inhibits growth of the *Erwinia tracheiphila in vitro*, i.e. on agar plates, and blocked *Et* from establishing in beetle guts. We need to determine if this approach can be applied to commercial production systems. We have also shown that entomopathogenic nematodes (EPN) delivered through drip irrigation reduce larval survivorship by 50%. Research has also shown significant predation on the egg stage, and we have confirmed the presence of two species of parasitoids.

Chemical control: Systemic neonicotinoid seed treatments and/or application during planting, as well as foliar sprays (pyrethroids, carbamates, or foliar neonicotinoids) are effective. However, neonicotinoids has decreased rates of biocontrol services of insect predators and can impair pollinator health. Fruit production is dependent on pollination by bees. Growers rent honey bee colonies, and/or achieve pollination from wild populations of bees. We have >30 species of wild bees visiting cucurbit crops in Pennsylvania, and 75 to 99% of the ecosystem service of pollination is being provided by wild populations of squash bees and bumble bees in pumpkins in Pennsylvania. Sublethal exposure has been shown to reduce bumble bee food consumption, reproduction, worker survival rates, colony survival, and queen production. Organically approved insecticides are available, but relatively ineffective, and may also harm bees. In fact, we have demonstrated that organic soil management strategies may *increase* survival of the immature stages of cucumber beetle.

The replacement of systemics such as carbofuran (acute rat oral LD_{50} of 8 to 14) with neonicotinoids such as imidacloprid (acute rat oral LD_{50} of 380-450) was a dramatic improvement for farm-worker safety. Tactics to minimize bee exposure include: limiting neonics to just seed treatments, spraying only after the flowers close or very late in the evening, protect pollinator friendly areas of the farm (provide a refuge), provide floral resources (perrennials, or with selective management of cover crops), practice no-till, and avoiding the use of neonics on other crops when not needed. Another approach that could be effective to managing a pest that is a pathogen vector could be using other types of systemics. Recent field trials suggest that we can utilize diamides, such as Exirel, another type of systemic, to help manage cucumber beetles, and these diamides may pose less harm to bumble bees.

BEST ANNUALS OF THE PSU FLOWER TRIALS

Sinclair Adam, Penn State Extension Educator

The 2017 season brought cooler temperatures than in previous years and rainfall was above average. Nine hundred and thirty-one entries were evaluated in the season with four evaluations conducted during the growing season. Plants were laid out by their fertilizer requirements, and treated with liquid soluble and soil incorporated time-release fertilizer. Plants were treated with insecticide and fungicide as needed based on scouting reports conducted weekly by SEAREC staff and interns. Entries were rated for uniformity, flowering, foliar quality and overall growth. The ratings were averaged over the season for the final rating score. Thirty-two companies entered plants in the Penn State Flower Trials. Entries were submitted by firms from Japan, Israel, The Netherlands, and Germany, as well from the USA.

Best of The Penn State Flower Trials 2017

Alternanthera 2 cultivars

Best Performance: Purple Prince –PanAmerican Seed

Plum Dandy-Proven Winners

*Angelonia*10 cultivars

Best Performance: Archangel Dark Purple-Ball FloraPlant

Alonia Pink Flirt-Danziger Flower Farm

AngelMist Spreading Bluebird-Ball FloraPlant

Alonia Snow Ball-Danziger Flower Farm

Archangel Blue Bicolor-Ball FloraPlant

Archangel Cherry Red-Ball FloraPlant

Angelface Super White-Proven Winners

Argyranthemum 7 cultivars

Best Performance: Golden Butterfly-Proven Winners

Pure White Butterfly-Proven Winners

Vanilla Butterfly-Proven Winners

Grandessa Red-Suntory Flowers

Grandessa White-Suntory Flowers

Artemesia 1 cultivar Quicksilver-Proven Winners

Sinclair Adam is a Penn State Extension Educator in Horticulture, and Penn State Flower Trials Director. He holds a B.S. in Plant and Soil Science from Univ. of Wyoming, and a M.S. in Plant and Soil Science from the Univ. of Vermont. Sinclair has been an Adjunct Professor at Univ. of Vermont, a Senior Lecturer at Temple University, a Research Fellow at Temple University, and has taught at the Barnes Foundation. Sinclair has also served in the horticultural industry for over 30 years, and holds 15 plant patents on Phlox, Tiarella, and Chrysanthemum selections. 17

Begonia 46 cultivars

Best Performance:
- Be Adore X 74-HilverdaKooij
- Be Adore Amoretto-HilverdaKooij
- Be Adore Liebe-HilverdaKooij
- Be Adore Veramente-HilverdaKooij
- Big Rose Bronze Leaf-Ernst Benary of America
- Nonstop Mocca Bright Orange-Ernst Benary of America
- Surefire Rose-Proven Winners
- Unbelievable Red-Dummen Orange
- Megawatt Red Bronze Leaf-PanAmerican Seed
- Be Adore X91-HilverdaKooij
- Big Red Bronze Leaf-Ernst Benary of America
- Big Rose Green Leaf –Ernst Benary of America
- Nonstop Mocca Red-Ernst Benary of America
- Surefire Red-Proven Winners
- Whopper Rose Green Leaf Improved-Ernst Benary of America
- Be Adore Dragoste-HilverdaKooij
- Whopper Red Bronze Leaf Improved-Ernst Benary of America
- Megawatt Rose Bronze Leaf-PanAmerican Seed
- Be Adore Amanu-HilverdaKooij
- Megawatt Pink Bronze Leaf-PanAmerican Seed
- Solenia Apricot-Beekenkamp
- Carmen-Beekenkamp
- L'Conia Miss Malibu-Dummen Orange

Bidens 10 Cultivars

Best Performance:
- Beedance Yellow-Suntory Flowers
- Beedance Red Stripe-Suntory Flowers
- Blazing Fire –Danziger Flower Farm
- Pretty in Pink-Danziger Flower Farm
- Beedance Painted Red-Suntory Flowers

Caladium 6 Cultivars

Best Performance: Scarlet Flame-Classic Caladiums
Creamsickle-Classic Caladiums
Flare-Classic Caladiums

Calendula 5 Cultivars

Best Performance: Lady Godiva Orange-Proven Winners
Caleo Yellow-Syngenta Flowers

Calibrachoa 64 Cultivars

Best Performance: Unique White Improved-Kientzler North America
Superbells Coralina-Proven Winners
Superbells White Improved-Proven Winners
Superbells Double Orchid-Proven Winners
Bloomtastic Rose Quartz-Dummen Orange
Kabloom White-PanAmerican Seed
MiniFamous Double Silver Blue-Selecta One
Superbells Lemon Slice-Proven Winners
Superbells Plum Improved-Proven Winners
Million Bells Butter Pop-Suntory Flowers
MiniFamous Double Pink17-Selecta One
MiniFamous Neo White + Yellow Eye-Selecta One
Superbells Tropical Sunrise-Proven Winners
Unique Golden Yellow-Kientzler North America
Colibri Pink-Danziger Flower Fram
MiniFamous Double Amethyst-Selecta One
Superbells Over Easy-Proven Winners
Superbells Pomegranate Punch-Proven Winners
Superbells Rising Star-Proven Winners
Noa Cherry-Danziger Flower Farm

Calocephalus 1 Cultivar Bed Head-Ernst Benary of America

Canna 9 Cultivars

Best performance: Toucan Yellow-Proven Winners
CannaSol Cleo-Dummen Orange
South Pacific Ivory-American Takii
Toucan Coral-Proven Winners

Catheranthus 3 Cultivars

Best Performance: Coral-Kientzler North America

Celosia 6 Cultivars

Best Performance: Twisted Red Improved-Ball Ingenuity

Twisted Orange-Ball Ingenuity

Cleome 4 Cultivars

Best performance: Pequena Rosality-Proven Winners

Senorita Mi Amore-Proven Winners

Coleus (Solenstemon) 16 Cultivars

Best Performance: Flame Thrower Salsa Verde-Ball FloraPlant

Flame Thrower Chili Pepper-Ball Flora Plant

Great Falls Iguazu-Dummen Orange

Wasabi-Ball FloraPlant

Flame Thrower Chipotle-Ball FloraPlant

Flame Thrower Spiced Curry-Ball FloraPlant

Indian Summer-Ball FloraPlant

Great Falls Angel- Dummen Orange

Colocasia 1 Cultivar Hawaiian Aloha-Proven Winners

Combinations 27 Cultivars

Best Performance: Kwik Kombo Night in Pompeii-Syngenta Flowers

Confetti Garden Peppermint Candy-Dummen Orange

Kwik Kombo PlumTastic-Syngenta Flowers

MixMasters Big Flirt-Ball FloraPlant

MixMasters Spring Showers-Ball FloraPlant

Kwik Kombo Mom's Chosen One-Syngenta Flowers

MixMasters Mambo-Ball FloraPlant

Trixi Perfect Storm-Selecta One

Trixi Caribbean Cocktail 18-Selecta One

Combinations Hanging Basket 27 Cultivars

Best Performance: MixMasters Spring Showers-Ball FloraPlant

Trixi Perfect Storm-Selecta One

Confetti Garden Peppermint Candy-Dummen Orange

Trixi Caribbean Cocktail-Selecta One

	Kwik Kombo Night in Pompeii-Syngenta Flowers
	MixMasters Rose' Everyday-Ball FloraPlant
Coreopsis 1 Cultivar	SunKiss-Kieft Seed
Cuphea 2 Cultivars	
Best Performance:	Fairy Dust Pink-Proven Winners
Cyperus 2 Cultivars	
Best Performance:	Graceful Grasses Prince Tut-Proven Winners
Dahlia 50 Cultivars	
Best Performance:	LaBella Grande Purple-Beekenkamp
	LaBella Medio Red-Beekenkamp
	Gardenetta Passion Fruit-Ball FloraPlant
	Rebel Atom Ant-HilverdaKooij
	Rebel Elasti Girl-HilverdaKooij
	Rebel 132027-HilverdaKooij
	Hypnotica Lavender-Dummen Orange
	LaBella Maggiore Purple-Beekenkamp
	Dahlightful Crushed Crimson-Proven Winners
	Dahlightful Sultry Scarlet-Proven Winners
	Dalaya Shari-Selecta One
Dipladenia 2 Cultivars	
Best Peformance:	Summer Romance Blush Pink-Ball Ingenuit
Erysimum 3 Cultivars	
Best Performance:	Bowles Me Away-Darwin Perennials
Euphorbia 3 Cultivars	
Best Performance:	Crystal White-H. F. Michell/Green Fuse Botanicals
	Diamond Frost-Proven Winners
Evolvulus 1 Cultivar	Blue My Mind-Proven Winners
Fuchsia 6 Cultivars	
Best Performance:	Bella Fuchsia Vera-Beekenkamp
	Bella Fuchsia Vera Mariska-Beekenkamp
Gailardia 2 Cultivars	
Best Performance:	Mesa Red- Kieft Seed

Geranium (IS) 19 Cultivars

Best Performance: Calliope Large Pink-Syngenta Flowers
Calliope Large Burgundy-Syngenta Flowers
Calliope Medium Burgundy-Syngenta Flowers
Calliope Large Dark Red-Syngenta Flowers
Calliope Medium Crimson Flame-Syngenta Flowers
Big Eeze Pink-Dummen Orange

Geranium (Zonal) 27 Cultivars

Best performance: Patriot-J. P. Bartlett
Savannah Oh So Orange-Dummen Orange
Beth- J. P. Bartlett
Puritan II-J. P. Bartlett
Yours Truly- J. P. Bartlett
Abigail-J. P. Bartlett
Aspen White 08247-J. P. Bartlett
Brocade Cherry Night-Dummen Orange

Gerbera 5 Cultivars

Best Performance: Garvinea Sweet Glow-Florist Holland
Garvinea Sweet Smile-Florist Holland

Hypoestes 2 Cultivars Hypnotica Rose-Proven Winners

Impatiens (hybrida) 24 Cultivars

Best performance: Bounce Violet-Selecta One
SunPatiens Compact Hot Coral-Sakata Seed America
Big Bounce Lilac-Selecta One
Bounce Bright Coral-Selecta One
SunPatiens Compact White-Sakata Seed America
SunPatiens Compact Orchid-Sakata Seed America
SunPatiens Compact Royal Magenta-Sakata Seed America
SunPatiens Spreading Shell Pink-Sakata Seed America

Impatiens (NGI) 37 Cultivars

Best Performance: Paradise Electric Orange-Kientzler North America
SunStanding Purple-Dummen Orange

Paradise Rocco Cherry-Dummen Orange
ColorPower White-Selecta One
Paradise Select Peach-Kientzler North America
SunStanding Orange Aurora-Dummen Orange
Clockwork Appleblossom-Ball FloraPlant
Clockwork Orange Stripe-Ball FloraPlant
Divine Orange-PanAmerican Seed
Super Sonic Dark Red-Syngenta Flowers

Ipomoea 10 Cultivars

Best Performance: SolarPower Lime Improved-Ball FloraPlant
SolarTower Black-Ball FloraPlant
FloraMia Rosso-Dummen Orange

Sweet Caroline Bewitched Green With Envy-Proven Winners

Lantana 19 Cultivars

Best performance: Lucky Pot of Gold-Ball FloraPlant
Bloomify Red-Ball FloraPlant
Lucky Red-Ball FloraPlant
Luscious Royal Cosmo-Proven Winners
Havana Sunrise-Dummen Orange

Lavandula 2 Cultivars

Best Performance: Lavance Deep Purple-Kieft Seed

Lobelia 7 Cultivars

Best Performance: Starship Deep Rose-Kieft Seed
Suntory Lobelia Compact White-Suntory Flowers

Lobularia 2 Cultivars

Best Performance: Marineland White-H. F. Michell/GreenFuse Botanicals

Marigold 3 Cultivars

Best Performance: Bonanza Yellow-PanAmerican Seed

Melampodium 1 Cultivar Jackpot Gold-American Takii

Okra 1 Cultivar Jambalaya-Sakata Seed America

Origanum 1 Cultivar Kirigami-PanAmerican Seed

Millet 1 Cultivar Copper Prince-PanAmerican Seed

Ornamental Pepper 3 Cultivars

Best Performance: Midnight Fire-PanAmerican Seed

Osteospermum 8 Cultivars

Best Performance: Daisy Falls Pink-Selecta One

Bright Lights Double Moonglow-Proven Winners

Daisy Falls Purple-Selecta One

Daisy Falls White Amethyst -Selecta One

Pentas 1 Cultivar Falling Star Red-Syngenta Flowers

Pepper 2 Cultivars Candy Cane Red-PanAmerican Seed

Mad Hatter-PanAmerican Seed

Petchoa 5 Cultivars

Best Performance: SuperCal Buttercream-Sakata Seed America

SuperCal Cherry Improved-Sakata Seed America

SuperCal Neon Rose-Sakata Seed America

Petunia 99 Cultivars

Best Performance: Supertunia Vista Bubblegum-Proven Winners

Dekko White-Syngenta Flowers

Supertunia Hot Pink Charm-Proven Winners

Supertunia Pink Star Charm-Proven Winners

Supertunia Vista Silverberry-Proven Winners

Supertunia Lovie Dovie-Proven Winners

Supertunia Picasso in Purple-Proven Winners

Blanket Blue Star-H. F. Michell/GreenFuse Botanicals

ColorRush Pink-Ball FloraPlant

Suntunia Neon Rose-Dummen Orange

Supertunia Vista Fuchsia-Proven Winners

Veranda Magenta-Kientzler North America

Veranda Sky Blue-Kientzler North America

Dekko Electric Rose-Syngenta Flowers

Dekko Salmon-Syngenta Flowers

Supertunia Electric Apricot-Dummen Orange

Surfina Deep Red-Suntory Flowers

ColorRush Blue-Ball FloraPlant

Easy Wave Blue-PanAmerican Seed

Supertunia Violet Star Charm-Proven Winners

Surfinia Summer Double White-Suntory Flowers

Phlox 11 Cultivars

Best Performance: Intensia Blueberry-Proven Winners

Gisele Hot Pink-Selecta One

Gisele Light Pink-Selecta One

Gisele Pink-Selecta One

Gisele White-Selecta One

Phloxstar Red-Danziger Flower Farm

Portulaca 7 Cultivars

Best Performance: Pazzaz Nano Fuchsia-Danziger Flower Farm

Pazzaz Nano Yellow-Danziger Flower Farm

Salvia 15 Cultivars

Best Performance: Mystic Spires-Ball FloraPlant

Playin' The Blues-Proven Winners

Salvia Mysty-Ball FloraPlant

Cathedral White-H. F. Michell/Green Fuse Botanicals

Cathedral Deep Blue-H. F. Michell/GreenFuse Botanicals

Cathedral Purple-H. F. Michell/Green Fuse Botanicals

Grandstand Blue Bicolor-H. F. Michell/GreenFuse Botanicals

Grandstand Red-H. F. Micell/GreenFuse Botanicals

Scaevola 7 Cultivars

Best Performance: Scampi White-H. F. Michell/GreenFuse Botanicals

Surdiva Blue Violet-Suntory Flowers

White Touch-Danziger Flower Farm

Pink Blessing-Danziger Flower Farm

Sutera 8 Cultivars

Best performance: MegaCopa White-Ball FloraPlant

Betty White-H. F. Michell/GreenFuse Botanicals

MegaCopa Blue-Ball FloraPlant

Scopia Gulliver Pink-Danziger Flower Farm

Thunbergia 3 Cultivars

Best Performance: A-Peel Tangerine Slice-Proven Winners

A-Peel Lemon Slice-Proven Winners

Tomato 8 Cultivars

Best Performance: Ruby Crush Hybrid-Sakata Seed America

Little Birdy Yellow Canary-Sakata Seed America

Verbena 36 Cultivars

Best Performance: Superbena Meteor Shower-Proven Winners

Empress Sun Red-Dummen Orange

Superbena Royal Peachy Keen-Proven Winners

Lascar Dark Red-Selecta One

EnduraScape Purple Improved-Ball FloraPlant

EnduraScape Red-Ball FloraPlant

Lanai Upright Limoncello-Syngenta Flowers

Zinnia 7 Cultivars

Best Performance: Profusion Yellow-Sakata Seed America

Profusion White-Sakata Seed America

Zahara Raspberry Ripple-PanAmerican

extension.psu.edu

Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

BASIC PLANT NUTRITION - UNDERSTANDING WATER, MEDIA AND FERTILIZER RELATIONS

Fred Hulme, Ph.D., Technical Service, Horticulture ICL Specialty Fertilizer;
email: fred.hulme@icl-group.com

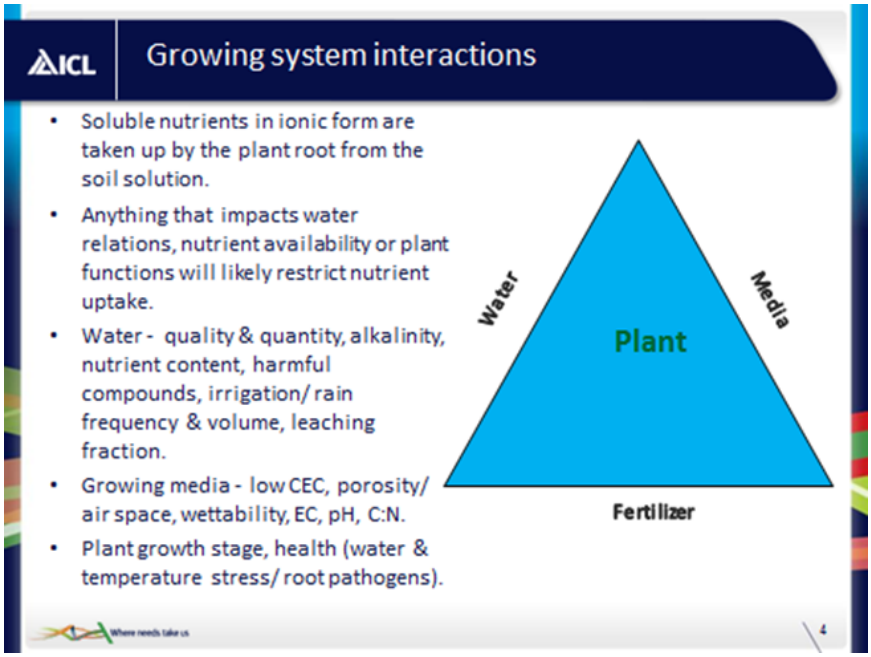
Essential Elements are required for normal life cycle of plants and whose function cannot wholly be substituted by other chemical components.

- Macro-Nutrients (%) from Air & Water: Carbon (C), Hydrogen (H), Oxygen (O)
- Macro- and Secondary Nutrients (%) from Fertilizers & Soil: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S)
- Trace/Minor Nutrients (ppm) from Fertilizers & Soil: Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Zinc (Zn)

Plant Nutrients (Mobility), Roles, Deficiency Symptom - Deficiency symptoms are a combination of metabolic role & mobility in the plant

- Nitrogen (mobile): proteins, chlorophyll / yellowing lower leaves 1st, stunting.
- Phosphorus (mobile): energy transfer, nucleic acids / purpling leaves, stunting.
- Potassium (mobile): enzyme activator, water relations / marginal lower leaf burn.
- Calcium (immobile): cell walls & membranes / growing point disorders.
- Magnesium (mobile): chlorophyll, enzyme activator / interveinal chlorosis.
- Sulfur (moderately mobile): proteins, vitamins / yellowing upper leaves 1st.
- Boron (immobile): calcium metabolism / growing point disorders.
- Copper (immobile): chloroplast protein, electron transport / terminal growth stunted.
- Iron (immobile): chlorophyll, respiration / yellowing upper leaves 1st.
- Manganese (immobile): photosynthesis, enzyme activator / interveinal chlorosis upper leaves 1st.
- Molybdenum (immobile): nitrate reductase / marginal upper leaf burn.
- Zinc (immobile): enzyme activator / mottle-leaf, little leaf.

Fred Hulme, Ph.D., Technical Service, ICL Specialty Fertilizer.
Biographical Information:
1. Current position and employer along with your responsibilities, duties and/or areas of research interest: Technical Services Director, Ornamental Horticulture for ICL Specialty Fertilizer serving the greenhouse and nursery markets in USA & Canada. Primary focus is on product development, technical marketing and sales support, problem solving and product training. He has had extensive experience with the Osmocote controlled-release and Peters water-soluble fertilizer lines, The Everris Testing Lab (as well as professional growing media business) since 1989.
2. Former positions and employers: Technical Service/Product Development and Sales with W.R. Grace, Grace-Sierra, Sun Gro, Scotts and Everris.
3. Degrees earned and schools attended: B.S. and M.S. degrees in Plant & Soil Sciences from the University of Massachusetts and a Ph.D. in Ornamental Horticulture Cornell University.
4. Where you are from originally: Boston, MA.
5. Spouse and children: wife and two children.

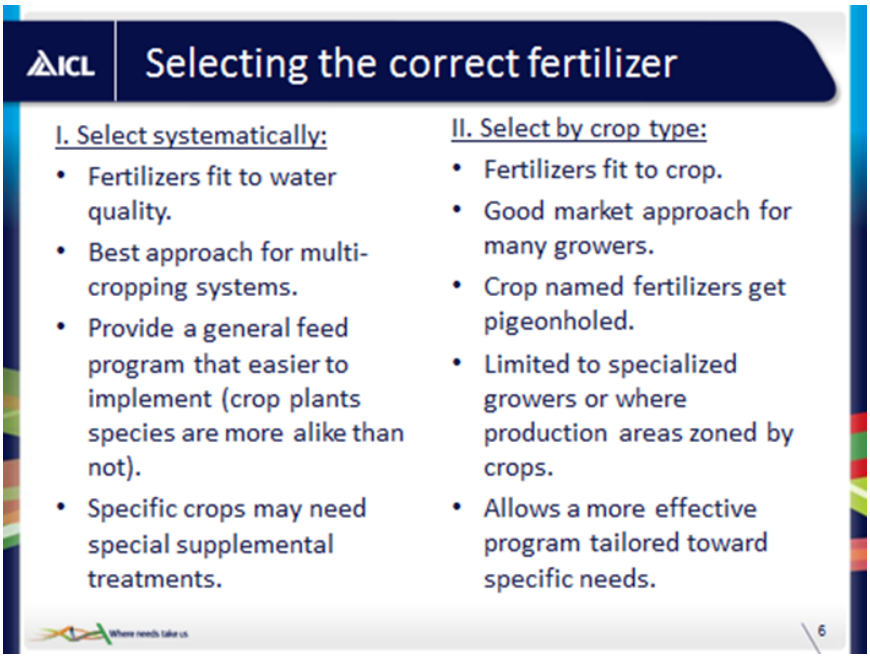


Nutrients are impacted by growing system

Factors determining the pH of Soilless Media

- pH of medium components (peat, bark, coir, etc.)
- Amount of limestone added to mix
- Alkalinity/ buffering capacity of irrigation water
- How media is sampled and how pH is measured
- Type of fertilizer used
- Concentration and frequency of fertilizer applications
- Crop grown

Strategies for Selecting a Fertilizer Program



Fertilizer BMP's:

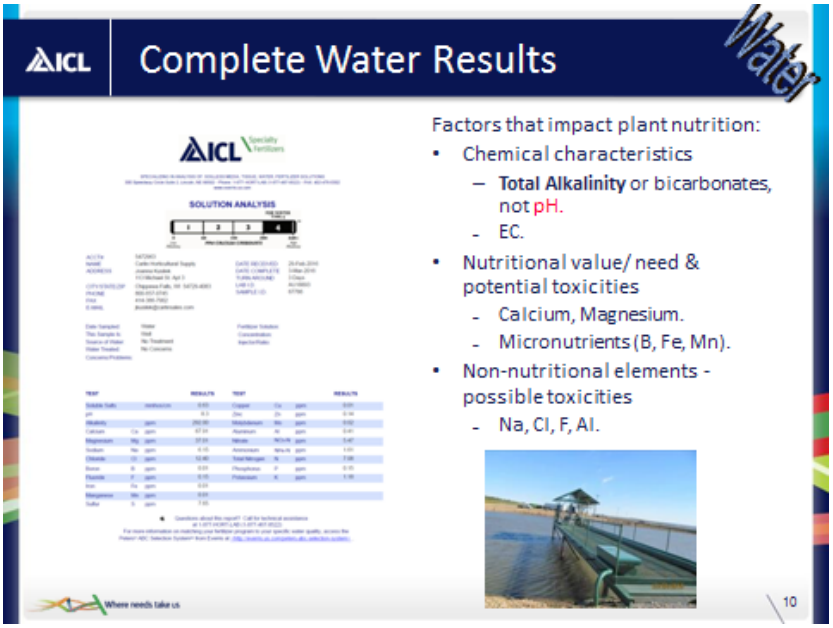
- Proper fertilizer selection to fill nutrient gaps
- Proper use - correct rates or concentrations & ratios at the right time
- Employing best management practices for a variety of crops
- Regular measuring & monitoring crops

Why Test?

- Because something is wrong
- To monitor progress of a crop
- To catch a situation before it becomes a problem
- To compare to previous crop's performance
- To determine why a crop is doing so well

Do comparative sampling (both media & tissue) to diagnose problems.

Irrigation Water Quality



ICL Testing Lab - SPECIALIZING IN ANALYSIS OF: SOILLESS MEDIA, TISSUE, WATER, FERTILIZER SOLUTIONS - 300 Speedway Circle, Suite #2, Lincoln, NE 68502 - Phone: 1-877-HORT-LAB (1-877-467-8522) - FAX: 402-476-0302. https://icl-sf.com/us-en/icl-testing-lab/

Nuts & Bolts Fertilizer(s) Selection

- Test report provides attributes & shortcomings
- Select fertilizers to fill in the gaps
- Water quality is a 'moving target', don't assume that "my water is always the same"
- Keep it simple
- There may be various programs that work
- Be flexible. Realize that adjustments and 'fine tuning' are what make us growers

MEALYBUG MANAGEMENT

Raymond A. Cloyd
Department of Entomology, Kansas State University, 123 Waters Hall, Manhattan, KS 66506-4004

Mealybugs are destructive and economically important insect pests of greenhouse-grown horticultural crops. Mealybugs are a major insect pest due to a number of factors including: 1) located in very secluded (cryptic) habitats, which makes detection difficult and ability to obtain contact with insecticides a challenge; 2) early instars (crawlers) are hard to detect; 3) later instars and adults develop a protective waxy covering that inhibits the effectiveness of contact insecticides; 4) mealybug females have high reproductive capacity (laying over 400 eggs); and 5) mealybugs feed on a wide-range of plant types. Mealybugs tend to feed in cryptic habitats thus escaping exposure from visual observations, spray applications of insecticides, and natural enemies (=biological control agents). Furthermore, mealybugs reside and hide underneath the sheaths of orchids. The crawlers are most susceptible to insecticides because they have not formed the protective waxy covering. The primary mealybug species encountered in greenhouse production systems is the citrus mealybug, *Planococcus citri*.

BIOLOGY

Mealybugs feed within the vascular system (phloem sieve tubes) removing plant fluids. Damage associated with mealybug feeding includes: leaf distortion, plant stunting, and wilting. Moreover, mealybugs exude copious amounts of honeydew while feeding. Honeydew is a clear, sticky liquid that serves as a growing substrate for black sooty mold. Ants will feed on the honeydew and protect mealybugs from natural enemies; such as, parasitoids and predators, and will distribute mealybugs among plants. The life cycle (egg to adult) takes 25 to 60 days depending on temperature. Males develop into winged individuals that mate with females. Males do not feed on plants as they do not have functional mouthparts. After mating, females continue development, lay their complement of eggs, and eventually die.

PLANT PROTECTION

Plant protection against mealybugs involves cultural, physical, insecticidal, and biological strategies. Below are the cultural strategies that must be implemented to avoid problems with mealybugs:

1) Avoid plant stress by maintaining healthy growth.

2) Use plant varieties or cultivars that are less susceptible to mealybugs (if possible).

3) Avoid over-fertilizing plants (especially with water-soluble nitrogen-based fertilizers) as

this increases female reproduction or causes females to lay more eggs than they would normally.

Physical strategies are those designed to quickly remove mealybugs from plants or from the production area. These include:

1) Washing crawlers off plants using a forceful water spray or using a brush to remove

mealybugs from plants.

2) Pruning out heavily-infested branches and removing plant debris from vicinity.

3) Immediately disposing of heavily-infested plants.

Dr. Raymond A. Cloyd is Professor and Extension Specialist in Horticultural Entomology/Plant Protection in the Department of Entomology at Kansas State University, Manhattan, KS. His research and extension program involves plant protection associated greenhouses, nurseries, landscapes, turfgrass, Christmas trees, converatories, interiorscapes, and vegetables and fruits. Dr. Cloyd has a B.S. degree in Ornamental Horticulture from the California Polytechnic State University—San Luis Obispo (San Luis Obispo, CA); and a M.S. and Ph.D degree in Entomology from Purdue University (West Lafayette, IN). He was formally a professor at the University of Illinois (Champaign-Urbana, IL). Originally from California, he and his wife Kimberly have a daughter, Allison.

When using insecticides to suppress mealybug populations, it is important to follow the guidelines provided below:

1) Repeat or multiple applications will be required as eggs do not all hatch simultaneously.

2) Rotate insecticides with different modes of action in order to minimize the potential of reistance developing in mealybug populations.

3) A surfactant or spreader-sticker (if not already in the formulation) should be added to the spray solution to enhance the spreadability of the spray droplets, which increases coverage of plant parts.

The types of insecticides used against mealybugs are contact and insect growth regulators. Contact insecticides will kill mealybugs by direct contact; whereas insect growth regulators are only active on the immature life stages (crawlers). Below are the ways to effectively use insecticides against mealybugs:

* Timing: apply insecticides when the most susceptible life stages (crawlers) are present.

* Coverage: when spraying an insecticide, be sure to obtain thorough coverage of all plant parts, including: leaves, stems, flowers, fruits, and the junction where the petioles meet the stem.

* Frequency: apply insecticides within timely intervals, which is dependent on the residual activity of a given insecticide. Always read the label for information associated with frequency of application.

Factors that may be responsible for insufficient suppression of mealybug populations when using insecticides include:

1) Failure to implement a scouting program.

2) Using inappropriate insecticides.

3) Poor coverage of plant parts with insecticide spray applications.

4) Improper timing of insecticide applications.

5) Extended insecticide application intervals (not frequent enough).

6) Failure to dispose of "pet" plants that serve as a reservoir for mealybug populations.

In our research program at Kansas State University (Manhattan, KS), we have found that systemic insecticides applied to the growing medium are not effective in suppressing citrus mealybug populations feeding on coleus plants, *Solenostemon* (=*Plectranthus*) *scutellarioides*. The reason for this may be associated with the following:

1) Although mealybugs feed in the phloem sieve tubes, similar to aphids and whiteflies, they feed differently.

2) Feeding involves variations in the number and length of time of intracellular punctures, intervals between the first phloem-ingesting periods, and stylet motility or movement during the phloem searching process.

3) Feeding behavior may impact the ability of systemic insecticides to suppress mealybug populations.

The use of biological control or natural enemies may be problematic due to the somewhat limited availability of natural enemies for regulation of mealybug populations. In addition, when implementing a biological control program it is critical to control ants, which protect mealybugs from their natural enemies. Below are the natural enemies (predators and parasitoids) commercially available for use against mealybugs:

Predators:

* Mealybug destroyer (*Cryptolaemus montrouzieri*)

* Green lacewing (*Chrysoperla* spp.)

Parasitoids:

* *Leptomastix dactylopii*

* *Anagyrus pseudococci*

CONCLUSION

In order to minimize problems with mealybugs: 1) immediately dispose of plants heavily-infested with mealybugs; 2) when using high-volume applications of insecticides, be sure to make frequent enough applications and thoroughly cover all plant parts; and 3) when implementing a biological control program be sure to control ants.

Below are two resources that contain information on how to suppress mealybug populations in greenhouse production systems:

Cloyd, R. A. 2011. Mealybug: Management in greenhouses and nurseries. Kansas State

University Agricultural Experiment Station and Cooperative Extension Service. MF-3001.

Kansas State University, Manhattan, KS. 4 pgs.

Cloyd, R. A. 2016. Greenhouse pest management. CRC Press, Taylor & Francis Group; Boca Raton, FL. 196 pgs. ISBN no. 978-1-4822-2778-9.

RESULTS OF THE PSU PERENNIAL PLANT TRIAL

Sinclair Adam, Penn State Extension

Perennials are tested for three years in-ground, and evaluated four times during the growing season. In 2017 rainfall was above average, and temperatures were cooler than typical. Six perennials of each entry are planted in Hagerstown silt loam, amended with compost, and fertilized with Nutri-tree granular fertilizer. After three years of testing, the plants are removed from the trials area.

1) *Achillea* Little Moonshine	Blooms of Bressingham
2) *Achillea* New Vintage Rose	Darwin Perennials
3) *Achillea* Ritzy Rose	Must Have Perennials
4) *Agastache* Little Adder	Darwin Perennials
5) *Agastache* Morello	Terra Nova Nurseries
6) *Alchemilla* Gold Strike	Jelitto Perennials
7) *Allium* Windy City	Intrinsic Perennial Gardens
8) *Alstroemeria* Indian Summer	HilverdaKooij
9) *Alstroemeria* Summer Breeze	HilverdaKooij
10) *Armeria* Dreameria Sweet Dreams	Darwin Perennials
11) *Aster* Kickin Lavender	Cultivaris
12) *Aster* Kickin Silver Pink	Cultivaris
13) *Chrysanthemum* Peaches and Cream	NEthing Grows
14) *Coreopsis* Crème Caramel	Darwin Perennials
15) *Coreopsis* Uptick Yellow &Red	Darwin Perennials
16) *Dendranthema* Dainty Pink Igloo	Must Have Perennials
17) *Dianthus* Beauties Kate	Dummen Orange
18) *Dianthus* Kahori	Dummen Orange
19) *Echinacea* Moodz Glory	HilverdaKooij
20) *Echinacea* Moodz In Love	HilverdaKooij
21) *Echinacea* Sombrero Granada Gold	Darwin Perennials
22) *Echinacea* Sombrero Sangrita	Darwin Perennials
23) *Echinacea* Green Twister	Jelitto Perennials
24) *Erysimum* Golden Glow	Cultivaris
25) *Festuca* Cool as Ice	Intrinsic Perennial Gardens
26) *Gaillardia* Mesa Red	KieftSeed
27) *Gaillardia* Spintop Red	Dummen Orange
28) *Gaillardia* Spintop Yellow Touch	Dummen Orange
29) *Geranium* Azure Rush	Blooms of Bressingham
30) *Geranium* Miss Heidi	Darwin Perennials
31) *Helenium* Mariachi Sombrero	Plants Nouveau
32) *Heliopsis* Burning Hearts	Jelitto Perennials

Sinclair Adam is a Penn State Extension Educator in Horticulture, and Penn State Flower Trials Director. He holds a B.S. in Plant and Soil Science from Univ. of Wyoming, and a M.S. in Plant and Soil Science from the Univ. of Vermont. Sinclair has been an Adjunct Professor at Univ. of Vermont, a Senior Lecturer at Temple University, a Research Fellow at Temple University, and has taught at the Barnes Foundation. Sinclair has also served in the horticultural industry for over 30 years, and holds 15 plant patents on Phlox, Tiarella, and Chrysanthemum selections. 17

33) *Helleborus* x Winterbells	HilverdaKooij
34) *Heuchera* Carnival Fall Festival	Darwin Perennials
35) *Heuchera* Grape Soda	Terra Nova Nurseries
36) *Heuchera* Carnival Black Olive	Darwin Perennials
37) *XHeucherella* Honey Rose	Terra Nova Nurseries
38) *XHeucherella* Plum Cascade	Terra Nova Nurseries
39) *Kniphofia* Fire Dance KG041	Jelitto Perennials
40) *Lavandula* Platinum Blonde	Cultivaris
41) *Leucanthemum* White Magic	Darwin Perennials
42) *Lychnis* Petite Jenny	Blooms of Bressingham
43) *Miscanthus* Bandwidth	Darwin Perennials
44) *Monarda* Balmy Pink	Darwin Perennials
45) *Monarda* Balmy Purple	Darwin Perennials
46) *Penstemon* Rock Candy Ruby	Darwin Perennials
47) *Penstemon* Little Bells	Darwin Perennials
48) *Perovskia* Little Lace	Star Roses (Darwin)
49) *Phlox* Spring Lavender	Dummen Orange
50) *Phlox* Spring Light Pink	Dummen Orange
51) *Rudbeckia* American Gold Rush	Intrinsic Perennial Gardens
52) *Salvia* Blue Marvel	Darwin Perennials
53) *Salvia* Rose Marvel	Darwin Perennials
54) *Salvia* Salute Deep Blue	Dummen Orange
55) *Sedum* Pillow Talk	Intrinsic Perennial Gardens
56) *Sedum* Chocolate Cherry	Cultivaris
57) *Stokesia* Mel's Blue	Plants Nouveau
58) *Veronica* Venture Blue	Terra Nova Nurseries
59) *Veronica* Sky Blue Moody Blues	Darwin Perennials
60) *Veronica* Vernique Rose	H. F. Michell/Green Fuse

MANAGING WESTERN FLOWER THRIPS

Raymond A. Cloyd
Department of Entomology, Kansas State University, 123 Waters Hall, Manhattan, KS 66506-4004

Western flower thrips (WFT), *Frankliniella occidentalis*, is the primary thrips species encountered by greenhouse producers and feeds on a wide-variety of horticultural crops grown in commercial greenhouse production systems including: ornamentals and vegetables. Western flower thrips are approximately 2.0 mm in length and possess piercing-sucking mouthparts. The life cycle consists of an egg stage, two larval stages, two pupal stages, and an adult. In general, the life cycle (egg to adult) takes 2 to 3 weeks to complete; however, development or generation time from egg to adult is temperature dependent, with an optimum range of 26 to 29°C (79 to 84°F). Under these temperatures, the life cycle from egg to adult can be completed in 7 to 13 days. Females can live up to 35 days and lay up to 300 eggs during their lifetime. Females mainly feed on flower pollen, which contains nutrients, such as; carbohydrates, proteins, sterols, and vitamins that enhance their development rate and reproductive capacity. Females typically lay eggs underneath the epidermal layer of the leaf surface or in flower tissues, which provides protection from contact insecticides. Eggs hatch in 2 to 4 days. The larvae feed on leaves and flowers. The first larval stage lasts 1 to 2 days while the duration of the second larval stage is 2 to 4 days. Second instar larvae are typically more active and tend to feed more than first instar larvae. Second instar larvae eventually migrate to the base of a plant and enter the growing medium to pupate. However, WFT will also pupate in leaf debris, on the plant, and in the open flowers of certain plant types including chrysanthemum. There are two pupal stages: prepupae and pupae. Both stages commonly occur in growing medium or soil underneath benches. The pupal stages do not feed and are very tolerant or immune to most insecticides commonly applied to manage or suppress populations of WFT larvae and adults. Adults eclose from the pupal stage after approximately 6 days. Although WFT adults have wings, they do not fly very well, and are dispersed throughout a greenhouse via air currents created by horizontal airflow fans or wind entering from outside. Western flower thrips are commonly located in secluded habitats on plants such as un-opened leaf or flower buds, which protect them from exposure to contact insecticides and natural enemies.

Western flower thrips cause direct damage by feeding on plant leaves and flowers. Although WFT have piercing-sucking mouthparts, they do not feed exclusively in the phloem sieve tubes like aphids and whiteflies. Instead they feed within the mesophyll and epidermal cells of leaf tissues using a single stylet in the mouth and then inserting a set of paired stylets, which lacerate and damage cell tissues and function to imbibe cellular fluids. Symptoms of WFT feeding include leaf scarring, distorted growth, sunken tissues on leaf undersides, and deformation of flowers. Flowers and leaves have a characteristic "silvery" appearance due to the influx of air after the removal of plant fluids. Black fecal deposits may also be present on leaf undersides. Damage to plant leaves may occur when females, using their sharp ovipositor, insert eggs into plant tissue. Furthermore, the wounds created by WFT during feeding or oviposition may serve as entry sites for plant pathogenic organisms; such as fungi. In addition, western flower thrips cause indirect damage by vectoring the tospoviruses: *Impatiens necrotic spot wilt virus* and *Tomato spotted wilt virus*. The first and second instar larvae acquire the virus, which is then transmitted by adults. Both direct and indirect damage can result in an economic loss to greenhouse producers.

Western flower thrips is difficult to manage in greenhouses for a number of reasons including: 1) broad host range, 2) high female reproductive capacity, 3) rapid life cycle (egg to adult), 4) small size (approximately 2.0 mm long), 5) feeding habit, 6) reside in cryptic habitats (un-opened flower buds), and 7) resistance to insecticides. Therefore, the way to effectively deal with WFT populations in greenhouse production systems is by taking a "holistic" approach via implementing a variety of strategies including: scouting, cultural and physical, insecticidal, and biological management.

Dr. Raymond A. Cloyd is Professor and Extension Specialist in Horticultural Entomology/Plant Protection in the Department of Entomology at Kansas State University, Manhattan, KS. His research and extension program involves plant protection associated greenhouses, nurseries, landscapes, turfgrass, Christmas trees, converatories, interiorscapes, and vegetables and fruits. Dr. Cloyd has a B.S. degree in Ornamental Horticulture from the California Polytechnic State University—San Luis Obispo (San Luis Obispo, CA); and a M.S. and Ph.D degree in Entomology from Purdue University (West Lafayette, IN). He was formally a professor at the University of Illinois (Champaign-Urbana, IL). Originally from California, he and his wife Kimberly have a daughter, Allison.

SCOUTING

Scouting or monitoring is important to determine the presence or absence of WFT in the greenhouse during the growing season. Moreover, scouting will detect seasonal trends in WFT populations throughout the year and help to time insecticide applications. The main technique used to scout for WFT adults is to position yellow or blue sticky cards above the crop canopy; although there is still disagreement on which color is the most attractive to WFT. The number of WFT adults is counted on the cards and the data is recorded. Visual inspection such as looking into open flowers, and/or shaking open flowers over a white sheet of paper are additional methods that can be used to scout for WFT larvae and adults. Furthermore, gently blowing into open flowers will agitate WFT and increase their movement, thus making it easier to observe them.

CULTURAL AND PHYSICAL MANAGEMENT

Sanitation practices such as removing weeds, old plant material and growing medium debris are the "first line of defense" in minimizing problems with WFT. Certain weeds, particularly those in the Compositae (chrysanthemum) and Solanaceae (potato) families, and those with yellow flowers, not only attract WFT adults, but many weeds serve as reservoirs for the viruses transmitted (vectored) by WFT adults. Therefore, weeds must be removed from both inside and around the greenhouse perimeter.

Furthermore, immediately discard plant material debris from the greenhouse or place plant material debris into containers with tight-sealing lids since WFT adults will abandon desiccating plant material and migrate onto the main crop. Screening greenhouse openings; such as, vents and sidewalls will reduce populations of adult WFT entering greenhouses from outside or migrating into other greenhouses. The appropriate screen size or mesh for WFT is 192 μm (0.037 mm^2) or 100 mesh. Screening may alleviate problems with WFT moving from field-grown crops such as corn and soybean, and field-grown vegetables into greenhouses; however, screening will not be effective if doors are continuously left open or if plant material already infested with WFT is moved among greenhouses.

Alternative cultural and/or physical management strategies that may be implemented include: 1) over-head irrigation or misting has been shown to decrease the abundance of WFT populations, by creating an environment less favorable for development; 2) use of ultraviolet absorbing plastic films appear to influence WFT adult flight behavior by reducing the levels of ultra-violet light entering greenhouses or aluminized reflective fabrics that inhibit or repel WFT adults from entering greenhouses; 3) mechanically brushing plants has shown to reduce WFT damage in greenhouse-grown vegetables; 4) and placing a weed fabric barrier underneath benches, thus preventing WFT from entering the soil to pupate. Greenhouse producers can then routinely use mechanical vacuums or blowers to distribute pupae (along with any plant and/or growing medium debris) into concentrated areas that are then collected, and disposed of promptly. The use of vacuums or blowers may be one strategy to deal with the pupal stages in which there are no effective controls.

Another strategy that may be helpful in managing WFT is the use of trap or lure crops, which are plants (and flowers) that attract WFT away from the main crop. These plants and/or flowers may be sprayed with an insecticide, removed from the greenhouse, or inoculated with biological control agents such as predatory mites or predatory bugs that will feed on the larvae and/or adult stages residing in the flowers.

INSECTICIDES

Since the tolerance for WFT damage on most greenhouse-grown horticultural crops is relatively "low," the primary plant protection strategy used to deal with WFT in greenhouses involves the use of insecticides. The key to managing WFT with insecticides is to initiate applications when populations are "low," which avoids dealing with different age structures or life stages (eggs, larvae, pupae, and adults) present simultaneously over the course of the crop production cycle. Once WFT populations' reach "high" levels, then more frequent applications at 3 to 5 day intervals may be required. Insecticides must be applied prior to WFT entering terminal or flower buds, as once they do, it is very difficult to obtain adequate suppression, and thus prevent damage. Insecticides with contact or translaminar activity are generally used to suppress WFT populations because systemic insecticides, when applied to the growing medium, typically do not move into flower parts (petals and sepals) where WFT adults feed. Those insecticides

with translaminar activity, which means the material penetrates and resides in the leaf tissues forming a reservoir of active ingredient, provide residual activity even after spray residues have dried. Therefore, translaminar insecticides are more likely to be effective in killing WFT in terminal or flower buds. Applications conducted after flowers open are generally too late since damage has already occurred. High-volume sprays are typically required to reach WFT that are located in hidden areas of plants such as un-opened flower buds.

Most currently available insecticides only kill the larvae or adult, with no activity on either the egg or pupal stages. Consequently, repeat applications are required in order to kill the life stages that were not affected by previous applications, such as larvae that were in the egg stage and adults that were in the pupal stages. Repeat applications are especially important when overlapping generations are present. Three to 5 applications within a 7 to 14 day period may be needed to obtain sufficient suppression when WFT populations are "high" and there are different life stages (eggs, larvae, pupae, and adults) and/or overlapping generations present. However, frequent applications may lead to resistance developing in WFT populations. Frequency of application depends on the time of year (season), as during cooler temperatures (winter) the life cycle is extended compared to warmer temperatures (spring through early fall), which will influence the number of applications required. There are a variety of reasons for poor suppression of WFT populations with insecticides including: spray timing, which is associated with the age structure of WFT populations; spray coverage; pH of spray solution; frequency of applications; and migration of WFT into greenhouses from outdoors. **Table 1** lists some of the insecticides registered for thrips and their corresponding modes of action.

RESISTANCE

The sole reliance on insecticides to deal with WFT populations in greenhouses will eventually lead to populations developing resistance. For example, certain WFT populations are resistant to a number of chemical classes including: organophosphate, carbamate, pyrethroid, and macrocyclic lactone. The main reason is that WFT have a breeding system (haplo-diploid) that accelerates the development of resistance. In addition, the international trade of plant material may not only spread WFT populations but may also indirectly spread populations of WFT containing resistance genes or specific resistance mechanisms.

The primary way to minimize WFT populations from developing resistance and prolong the effectiveness of currently available insecticides is by rotating insecticides with different modes of action. In general, rotate different modes of action every 2 to 3 weeks or within a generation. However, this depends on the time of year since the development time of the life cycle is temperature dependent. Again, **Table 1** lists some of the insecticides registered for thrips and their corresponding modes of action.

BIOLOGICAL MANAGEMENT

Biological control of WFT relies on using natural enemies including: the predatory mites, *Neoseiulus cucumeris*, *Iphiseius degenerans*, *Amblyseius swirskii*, *Stratiolaelaps miles*, and *Geolaelaps aculeifer*; the insidious flower bug, *Orius insidiosus*; the rove beetle, *Dalotia coriaria*; the entomopathogenic or insect-killing nematode, *Steinernema feltiae*; and the entomopathogenic fungus, *Beauveria bassiana*. The predatory mites feed on the first and/or second instar larvae of WFT with the exception of *S. miles* and *G. aculeifer*, which are predatory mites that reside in the soil or growing medium feeding on the pupal stages.

When using natural enemies to regulate WFT populations, it is important to avoid intraguild predation, which is when one predator feeds on another predator when both are occupying the same habitat. This commonly occurs when generalist predators are used in biological control programs. For example, both *N. cucumeris* and *Orius* spp. engage in intra-guild predation under different cropping systems, and may feed on pollen more so than on WFT, which will inhibit the regulation of WFT populations among greenhouse-grown crops.

Biological control of WFT, in general, can be very difficult or more challenging than using insecticides. However, the key to implementing a successful biological control program is to release natural enemies early in the crop production cycle. Releases must be initiated prior to WFT entering terminal or flower buds. Natural enemies will not regulate an already established or existing "high" WFT population because it takes time from release before natural enemies will lower WFT numbers below damaging levels. Biological control tends to work best on long-term crops

like cut flowers or perennials more so than crops such as bedding plants, which typically have short production cycles (four to six weeks).

For more information on western flower thrips management, refer to the following publications:

Cloyd, R. A. 2012. Western flower thrips management on greenhouse-grown crops. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2922. Kansas State University, Manhattan, KS. 8 pgs. http://www.ksre.edu/library/entml2/mf2922.pdf

Cloyd, R. A. 2016. Greenhouse pest management. CRC Press, Taylor & Francis Group; Boca Raton, FL. 196 pgs. ISBN no. 978-1-4822-2778-9.

Table 1. Common name (=active ingredient), trade name, and mode of action of insecticides commercially available and registered for thrips (including western flower thrips) in greenhouse production systems.

Active Ingredient (common name)	Trade Name	Mode of Action
Abamectin	Avid	GABA[1] chloride channel activator
Acephate	Orthene/Precise	Acetylcholine esterase inhibitor
Azadirachtin	Azatin/Ornazin/Molt-X/ AzaGuard	Ecdysone antagonist: inhibits action of molting hormone
Beauveria bassiana Strain GHA	BotaniGard	
Bifenazate + Abamectin	Sirocco	Mitochondria electron transport inhibitor + GABA chloride channel activator
Bifenthrin	Attain/Talstar	Prolong opening of sodium channels
Chlorfenapyr	Pylon	Oxidative phosphorylation uncoupler
Cyantraniliprole	Mainspring	Selective activation of ryanodine receptors
Chlorpyrifos	DuraGuard	Acetylcholine esterase inhibitor
Cyfluthrin	Decathlon	Prolong opening of sodium channels
Fenoxycarb	Preclude	Juvenile hormone mimic
Flonicamid	Aria	Selective feeding blocker/chordotonal organ modulator
Fluvalinate	Mavrik	Prolong opening of sodium channels
Kinoprene	Enstar	Juvenile hormone mimic
Metarhizium anisopliae Strain F52	Met52	
Methiocarb	Mesurol	Acetylcholine esterase inhibitor
Mineral oil	Ultra-Pure Oil/SuffOil-X	Suffocation or membrane disruptor
Novaluron	Pedestal	Chitin synthesis inhibitor
Pyridalyl	Overture	Unknown mode of action
Pyrethrins	Pyreth-It/Pyrethrum	Prolong opening of sodium channels
Spinosad	Conserve	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator
Tolfenpyrad	Hachi-Hachi	Mitochondria electron transport inhibitor

[1] GABA=Gamma-aminobutyric acid.

BIOPESTICDES: WHAT WE HAVE TRIED, WHAT HAS WORKED

Abby Seaman, NYS IPM Program, Cornell University (ajs32@cornell.edu); Chris Smart and Holly Lange, Section of Plant Pathology and Plant-Microbe Biology, SIPS, Cornell University; Brian Nault and Tony Shelton, Department of Entomology, Cornell University

We have conducted trials agains insect and disease pests of importance to organic vegetable growers for the past seven seasons.

Links to reports from our trials can be accessed at: https://nysipm.cornell.edu/agriculture/vegetables/organic-resources-vegetables

Here's a brief summary of our results so far:

- Xentari (Bt) and spinosad are effective against squash vine borer: Three weekly applications starting when the squash vine borer flights starts (at first chicory flowering or 900 base 50 degree days.
- Coppers remain the most effective allowed fungicide for many diseases
- A new Bt product (Trident) was effective against Colorado potato beetle
- There are a few effective options for Lepidopterous pests of crucifers:
  Azera, spinosad, and Bts
- There are several effective options for powdery mildew of cucurbits:
  potassium bicarbonate, sulfur, Regalia, mineral and plant oils
- No effective controls for cucurbit downy mildew
  Zonix was the best treatments to date, but only 2-3 weeks of control
- We have not found effective controls for striped cucumber beetle or swede midge
  In both cases Surround (kaolin clay) was the best treatment

Abby Seaman has worked with the New York State IPM Program for 24 years and is currently the Vegetable IPM Coordinator. She received a BS in Plant Protection and an MS in Entomology from Cornell University.

USING SHADE CLOTH TO INCREASE MARKETABLE YIELDS OF TOMATOES AND PEPPERS

Jerry Brust, IPM Vegetable Specialist, University of Maryland

Tomatoes and peppers are big money makers for most vegetable growers, but high quality fruit must be produced if you are going to receive a good price for your crop. There are several physiological disorders that affect tomato fruit such as fruit cracking, sunscald, yellow shoulders, fruit ripening disorders, internal whitening, blotchy ripening, catface, rain check, puffiness and others. These disorders appear in our fields usually beginning in mid-summer, around the first or second week of July, but can come on sooner and later depending on the season or the disorder. Selecting some varieties that do well in the mid-summer heat is one way to improve fruit quality, but these cultivars can have undesirable attributes that growers and their customers do not want. One way to reduce many of these physiological disorders (but not all) for any cultivar is by using shade cloths (Fig 1). These shade cloths are best used after the first clusters of fruit have reached golf-ball size and weather conditions call for prolonged periods of high heat and humidity.

I have been working with shade cloth in tomato over the last several years and the shades have worked remarkably well in increasing the marketable yields of many different cultivars of tomatoes by 20-50%. I use a 30% filtering shade (using any more than 30% tends to reduce yields and size of tomato fruit). The shade cloth is draped over the top of the tomato stakes and held down at both ends (Fig 1). I know this does not seem practical, but only the top ¼ of the plant needs to be covered (not shown) which means a grower could use shade cloth with a 5-6 ft width and have it as long as they wanted it. The shades can be used over and over for many years; the ones I am using have been in use now for 7 years. The shade cloth helps tomato plants come through very stressful weather conditions, i.e., high temperatures with high dew points and even heavy rains in much better shape than plants that were not covered. The benefit of using the shades is an increase in quality and size of tomato fruit, rarely in the number of fruit.

Although I only have talked about tomatoes, the shade cloth works well with peppers too. Plants are covered when early fruit reaches about mid-size. I stake my peppers and use the smaller stakes to support the shade cloth (30% shading) over the plants. Shaded fruit is 10-20% larger and has significantly fewer defects compared with non-shaded fruit.

Figure 2 shows harvest bins of tomato fruit with the bin on the left from plants that were covered from the second week of July while the bin on the right was from plants (same cultivar) not covered. These experiments were replicated 4, 6, and even 8 times in the field over several years and the results were always the same – an increase in marketable yield each year. Some years it was a 19% increase and some years it was a 48% increase. Once plants are covered, the shade cloth can stay on the rest of the season until harvest is over. We spray through the shade cloth with fungicides and insecticides. Foliar diseases were reduced for plants under shade compared with plants with no shade. A grower only has to invest in the shade cloth one time and if treated somewhat carefully it can last many years (my guess at least 10). I am not suggesting a grower should shade an entire field, but you might select a few of your cultivars that bring a very good price, but are prone to producing ugly tomatoes during stressful weather conditions and shade those.

As an example, this past season we had a very wet period in July for most of us in the mid-Atlantic. Some fields received repeated downpours of rain and had standing water while others did not receive as much rain. But in almost all of the tomato fields I visited this past summer I found a good amount (12-20%) of fruit with rain check

Gerald Brust is the IPM Vegetable Specialist at the University of Maryland located at the Central Maryland Research and Education Center near Upper Marlboro, MD. He is responsible for developing new IPM programs for insect pests and new nutrient management programs for vegetables for Maryland and mid-Atlantic growers. Before coming to Maryland he worked for four years for a private consulting company in south Florida developing bioIPM programs for the company's vegetable grower clientele. Prior to Florida he worked for Purdue University developing IPM programs for Midwestern vegetable growers. His wife, Karen Rane is the Director of the University of Maryland's Diagnostic Laboratory and their two children are in grad school. He has an MS degree from The Ohio State University and his PhD from North Carolina State University 2013

(fig 3). Rain check is the many, tiny concentric cracks that form on the shoulder of the fruit that can expand over time (fig 3). The cracks feel rough to the touch, and affected areas can take on a leathery appearance and do not develop proper color as fruit ripens.

Damage is most visible on exposed, mature green, and possibly breaker fruit after rains; but at times even small, immature green fruit can be affected. This problem is mostly observed on large, fresh-market tomatoes, rather than on smaller cultivars. The exact cause is not known, but appears to be related to exposure of the fruit to rain. Cultivars can vary in their susceptibility to rain check. In my shade studies this past year I did not find a single fruit under any of the shade canopies with rain check while the other uncovered tomatoes (same cultivars) had 10-20% rain check.

Fig. 1 Tomato row covered with a 30% shade cloth

Figure 2. The fruit on the left came from a shaded row the fruit on the right from an unshaded row. The one on the right has many smaller blotchy, split fruit than the shaded one.

Figure 3. Moderate to severe rain check on tomatoes makes them unmarketable

EASY STEPS TO DO BOOM SPRAYER CALIBRATION

Robert Pollock, Penn State Extension

STEP 1: Clean sprayer inside and out to remove pesticide residue.

STEP 2: Fill sprayer half full of water.

STEP 3: Check all components of sprayer for proper working order and no leaks.

STEP 4: Have a good set of nozzles on the sprayer.

Check pesticide label for specific nozzles to use with product.

Use a calibration or measuring cup marked in ounces to determine the output of each nozzle for a given length of time and pressure.

Calculate average output for all the nozzles on the boom. To calculate the average output: Add all the nozzle outputs together and then divide by the total number of nozzles.

Each nozzle output should be within 5% of the average for the boom. Take the average output and multiple by 0.05.

This amount will be added to the average output and then subtracted from the average output.

The range of all the nozzle amounts should be between the two numbers just calculated.

Replace any nozzle that does not fall within the 5% range. If two or more nozzles are worn and need replaced, a good recommendation is to replace all of the nozzles at the same time.

Let's try an example: Outputs on 6 nozzles was 23, 21, 22, 26, 24, and 22 ounces.

Add them all together to get 139 ounces.

Now divide by 6 to get an average output of 23 ounces per nozzle.

Next, calculate 5% by multiplying 23 by 0.05 to get 1.15. This is the amount to be added to and subtracted from the average output (of 23 ounces) to get the acceptable range. This comes to 21.85 to 24.15 ounces per nozzle. We can use the range of 22 to 24 ounces per nozzle.

Note that the nozzles with outputs of 21 and 26 ounces are outside of this range and those nozzles should be replaced. This procedure should be repeated to verify that all the output amounts are within the 5% range.

1/128th of an Acre Driving Distance for Calibration

Nozzle spacing	Driving distance
14 in.	292 ft.
16 in.	255 ft.
18 in.	227 ft.
20 in.	204 ft.
22 in.	186 ft.
24 in.	170 ft.
26 in.	157 ft.
28 in.	146 ft.
32 in.	127 ft.
34 in.	120 ft.
36 in.	113 ft.
38 in.	107 ft.
40 in.	102 ft.

Bob Pollock is a Penn State Extension Educator with 32 years' experience conducting educational programs in Horticulture, IPM, pesticide safety and 4-H for commercial and non-commercial audiences. He earned a B.S. in Horticulture in 1981 from Penn State. Bob is based in Indiana County and serves on the Extension Tree Fruit, Vegetable, and Green Industry teams. Bob and his wife Annette have two grown sons and reside in Indiana, PA.

ALLIUM LEAFMINER: LIFE CYCLE, LOCATION AND MANAGEMENT

Shelby J. Fleischer, Timothy Elkner, Dana Roberts, Tom Baker
Department of Entomology and Penn State Extension
The Pennsylvania State University, University Park, PA 16802

A new invasive insect – the allium leafminer (*Phytomyza gymnostoma*) - was first recorded in the Western Hemisphere from a farm in Lancaster County, from samples collected in December 2015. By the end of 2017, we confirmed its presence in throughout southeastern Pennsylvania, and New York, New Jersey, and Maryland. It is a small fly (a species in the family Agromyzidae) that is a specialist on plants in the Allium plant family. Although the full host range of this invasive species in our area is not known, we suspect it will utilize all Allium species. We have confirmed it in onion (*A. cepa*), leek (*A. porrum*), garlic (*A. sativum*), chives (*A. schoenoprasum*), garlic chives (*A. tuberosum*), an ornamental (*A. christophii x A. macleanii*), as well as weedy wild garlic (*A. vinaela*). Barringer et al. 2017 summarizes its initial finding and biology.

Allium leafminers overwinter as a pupae either within or in close association with allium leaf or bulb tissue. Adults emerge early in the spring. From our 2016 and 2017 surveys, spring emergence start in April and continue well into May. During that time, the adults are finding and laying eggs into whatever allium leaf tissue is available. Based on infestation patterns, it appears that adults are making choices among the alliums in a farmscape. We suspect this choice is influenced by allium species or variety, and also by the growth stage or age of the plant, relative to what other allium plants are available. Eggs hatch within the leaf, and larvae tunnel downward and pupate by late May or early June.

These pupae stop development during the summer months – they undergo a summer aestivation until fall. The pupae eventually restart their development, and hatch out as adults, in the fall. In our area, we've seen this 2nd fall generation start by mid to late September (about September 20th or soon thereafter). Fall adult flight continued into early November in 2016, but it 2017 it seemed to end earlier, by about the 2nd or 3rd week of October. These fall adults also lay eggs into allium leaf tissue, which hatch into larvae and develop into the pupae that will overwinter. Farms with a continuous supply of allium hosts, such as chives, onions, leeks, garlic, as well as weedy alliums, provide a host for both the spring and fall generation, and these farms may be most at risk.

Row covers during the adult flight periods should be effective at stopping adults from laying eggs into allium plant tissue. We've been evaluating various colors and patterns of sticky traps, in the hope of being able to use trap captures as a monitoring tool to determine when this flight activity occurs. Adults, however, appear to have a short lifespan, and efforts to monitor adult flight activity with various colors or patterns on sticky traps have resulted in very low capture rates. We have documented higher capture rates on traps that are yellow, black, or yellow with a black grid, as compared to several other colors, from on-farm trials.

Starting in fall 2017, we've been able to conduct trials at the Southeast Research and Extension Center in Landisville, PA where pupal and larval infestation rates enable us to test management approaches. With the intend of building towards a trap cropping management approach, one trial looked at whether the variety or plant age of bunching onions present in the fall influenced infestation rate. We compared 2 varieties, Nebuchan and Evergreen, planted from seed, and 5 plant ages (105 to 170 days from seeding), in a replicated split plot design. The number of leafminers per plant (summed for both larvae and pupae), which varied from 0 to greater than 15, did not follow a simple linear pattern. This was due to low infestation rates in the very youngest plants, which did not establish well and had a high weed pressure – it was hard to even find the small onion plants within the weeds of those subplots. If we deleted those subplots, and focus on the 4 plant age classes with strong allium leaf material growth, there was

Dr. Fleischer is on the faculty of the Department of Entomology at The Pennsylvania State University where he specializes in population dynamics of insects. He has been worked in vegetable agroecosystems for 25 years. He previously was a Research Scientist at Virgina Tech and Research Associate at Auburn University. He received his B.S. in Biology from St. Mary's College of Maryland, his M.S. in Entomology from Virgina Tech and his Ph.D. in Entomology from Auburn. A native of Washington, D.C., he and his wife Barbara have two daughters and three grandchildren

a significant linear decrease in leafminers per plant as plant age increased, in a pattern that was the same for both varieties, suggesting that the ovipositing 2nd generation females were preferring younger plants regardless of variety.

We evaluated 7 insecticides, including one for organic production, with leeks. In the controls, 78% of the plants contained 1 or more leafminers, they averaged 4.1, and reached 22 leafminers per plant. Of the 280 plants dissected across the whole trial, 18 exceeded 10, and 3 exceeded 20 leafminers per plant. We chose to limit timing and application methods to within labelled rates, which resulted in varying application timings among treatments, especially between foliar sprays and applications through drip irrigation. For the foliars, some had 6 applications about a week apart, whereas those with some systemic activity only had 4 applications with a wider spray interval. The drip options were limited to only 2 applications at a wide interval. Also, our drip applications used drip tape placed on the soil surface, as opposed to buried closer to the roots. Furthermore, the leeks were very large by the time the 2nd generation flight occurred, and we started applications about 1 week after initial findings of adults.

Under these conditions, the 2 foliar treatments (the diamide, Exirel, and the neonicotinoid, Scorpion) that we expect to have some systemic or translaminar activity reduced leafminer numbers compared to controls. When using a second measure, the number of damaged leaves, foliar applications of Scorpion and Radiant separated from controls. Considering both metrics together, the neonicotinoid Scorpion was the only material that reduced both leafminer numbers and number of damaged leaves per plot. An organic option, Azadirachtin, reduced pupal numbers, but not pupal + larval counts. Perhaps more frequent applications would show control. Surprisingly, drip applications with these same materials were not different than controls. We need to redesign this with drip tape placed closer to the roots and improved timings. Also, all of these insecticide approaches could differ markedly when working with onions or other alliums in the spring, as opposed to large leek plants in the fall. We were able to collect large numbers of pupa from these trials which we are holding with the hopes of obtaining adults we can work with for lab studies.

Finally, when it comes to management using insecticides, we had yet another valuable contrast in fall 2017. Close to this efficacy trial in leeks, we also had a large leek variety trial occurring over the same time frame. Four insecticide cover sprays that varied insecticide materials were used to protect these plants, and this was effective. In contrast to our 78% infestation rate in the controls of the leek efficacy trial, the leek variety trial had a 0.8% infestation rate (13 positives out of 1615 plants evaluated).

In summary, allium leafminer has 2 generations per year, and is established in about a third of Pennsylvania, and in several adjacent states. Farms with a series of allium plants and allium weeds are most at risk. Sanitation –creating a host free period during the spring or fall adult flight by adjusting which alliums you plant, or when you plant or harvest – may reduce risk, but the presence and concentration of wild alliums could compromise that management approach. Targeting adults with row covers or insecticides looks like a promising management option. More work is needed to (i) have a better monitoring method to know when the flights are occurring, and (ii) optimizing choices, application methods, and timing for different crops and production systems, for systemic or foliar options, including options allowable for organic production. Infestation patterns are beginning to reveal host choice behavior and/or variation in immature survivorship among allium species, varieties, and plant age, and as these become better defined they offer promise for management with trap cropping methods.

Barringer, L. E., S. J. Fleischer, D. Roberts, S. E. Spichiger, T. Elkner. 2017. The first North American record of the allium leafminer. J. Integrated Pest Management (DOI: 10.1093/jipm/pmx034)

MANAGING FLEA BEETLES IN BOTH COLE CROPS AND EGGPLANTS

Thomas P. Kuhar1 and James A. C. Mason2
1Professor and 2Graduate student– Dept. of Entomology,
Virginia Tech Department of Entomology, Blacksburg, VA
tkuhar@vt.edu

Flea beetles are conspicuous pests of vegetable seedlings, particularly eggplant and brassica vegetables such as collards, kale and cabbage. Flea beetles often attack young seedlings and feed in mass on leaves resulting in characteristic "shot-hole" appearances. High densities of these insects can riddle leaves with holes. In some crops severe feeding injury can retard plant growth, reduce yield, and potentially kill seedlings.

The overall impact of flea beetle feeding on eggplant and cabbage, or the efficacy and yield benefit of various insecticide controls is not fully known. Growers often wonder how much damage do these pests really cause and how should I best control them? Herein, we report on our current research on the flea beetle species complex attacking these crops in the mid-Atlantic U.S., the impact of their feeding injury on crop yield, and efficacy of various insecticide treatments for controlling this pest group.

Effect of flea beetle feeding injury on cabbage and eggplant yield

Field experiments were conducted in Whitethorne, VA in 2015 and 2016 to determine the impact of flea beetle feeding injury on crop yield of cabbage and eggplant. In both years, transplants of both crops were planted in mid-May into bare ground with drip irrigation. Plots were fertilized and weeds controlled according to commercial guidelines. Applications of neonicotinoid (dinotefuran and imidacloprid) and pyrethroid (bifentrhin) insecticides were made to certain plots in order to provide a range of low and high flea beetle pest pressure. Seedlings were assessed once per week for flea beetle feeding injury using a percent defoliation scale: 1= no defoliation; 2= 10-20% defoliation; 3= 21-40% defoliation; 4= 41-60% defoliation; 5= >60% defoliation. After 1 month of allowing flea beetles to feed and plants to suffer injury at various levels. A sample of 10 random plants from each of the five defoliation scale categories were marked in the field and these plants were treated with a high rate of Voliam Xpress, a broad spectrum insecticide that eliminated any further insect injury to the crop after the initial flea beetle seedling injury. At harvest, individual plant yield was assessed by taking the weight of cabbage heads or by counting the number of marketable eggplant fruit per plant over a 2-3 week harvest period.

<u>*Cabbage.*</u> The predominant flea beetle species attacking cabbage were the striped flea beetle (*Phyllotreta striolata)* and the crucifer flea beetle (*P. cruciferae)*. Flea beetle pest pressure was relatively high reaching as many as 50 beetles per plant. There was a significant effect of flea beetle defoliation on yield in 2015 and 2016 (Fig. 1). Results showed that as little as 20% defoliation to young cabbage plants resulted in significant yield loss (weight of cabbage heads). These data strongly suggest that flea beetles should be controlled in order to maximize yields.

Tom Kuhar is a Professor and Vegetable IPM Specialist in the Department of Entomology at Virginia Tech. Dr. Kuhar's research focuses on the ecology and integrated pest management of insect pests of potato and vegetable crops. He has published over 75 peer-reviewed papers and book chapters on insect pest management in agricultural crops and has given hundreds of presentations on the topic. He received his B.S. degree in biology from Towson, University, Towson, MD in 1992 and his Master's (1996) and Ph.D. (2000) degrees in entomology from Virginia Tech. He formerly worked as a postdoctoral research associate at Cornell University, Ithaca, NY researching alternative methods for managing vegetable pests. A native of Baltimore, MD, he and his wife, Stacey, who also works at Virginia Tech, have two children, Daniel and Brianna. Outside of work, his passion is playing, watching, and coaching team sports like softball, basketball, and volleyball.

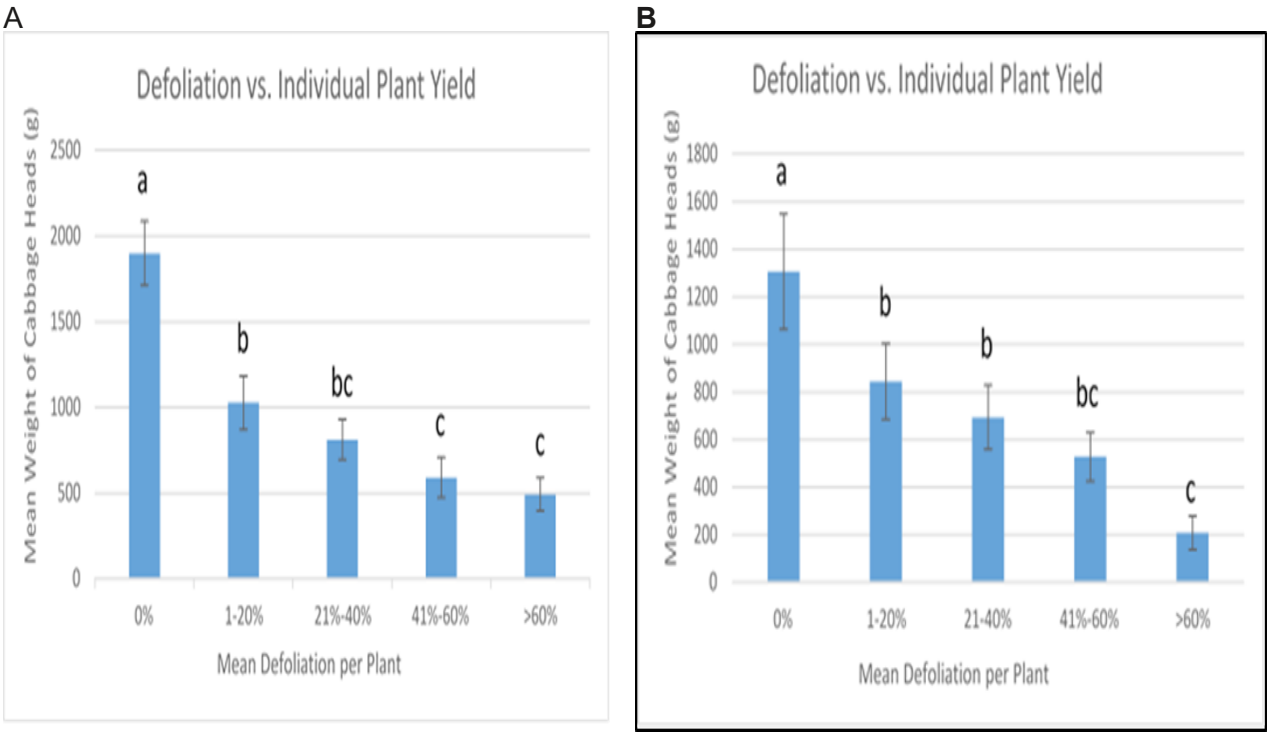


Fig. 1. Yield of 'Bravo' cabbage in 2015 (A) and 2016 (B) under increasing levels of flea beetle defoliation. Plants were transplanted in late May to early June. Plants were sprayed with Bt to control lepidopteran pests. One month after transplanting, all plants were treated with Voliam Express insecticide to eliminate any additional insect damage.

<u>*Eggplant.*</u> The predominant flea beetle species attacking eggplant was the eggplant flea beetle (*Epitrix fuscula)* with some tobacco flea beetle (*E. hirtipennis)* occurring on plants as well. As with cabbage, there was a significant effect of flea beetle defoliation on eggplant fruit yield in 2015 and 2016 (Fig. 2). Results showed that defoliation exceeding 21% resulted in significant yield loss in number of market-sized fruit per plant. Clearly, flea beetles need to be effectively controlled in this crop as well in order to maximize yields.

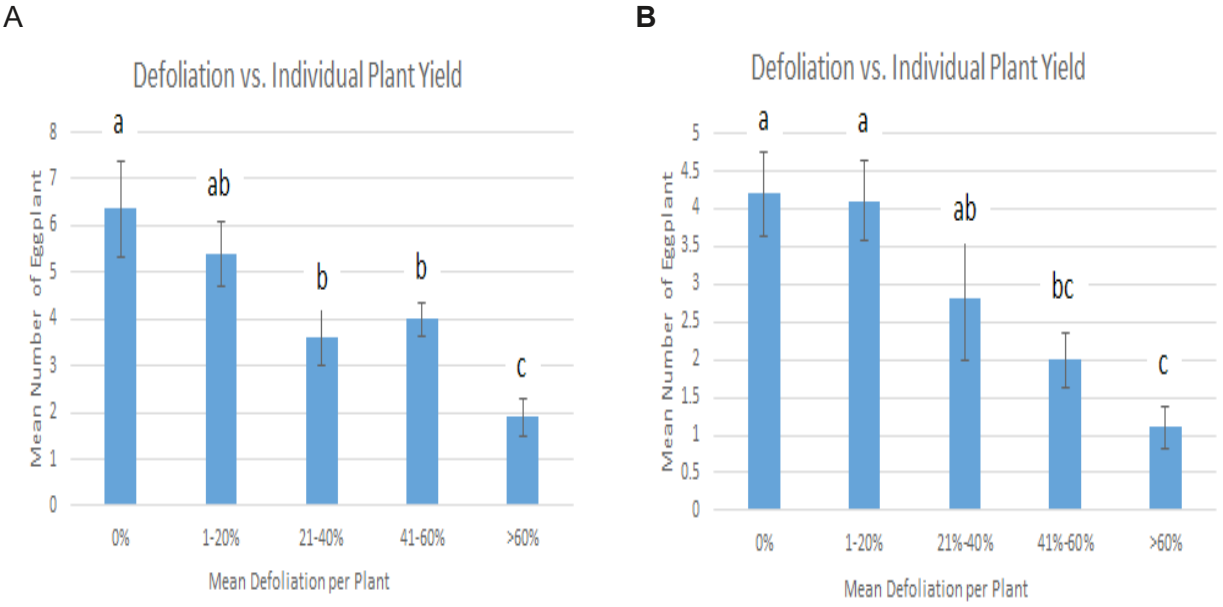


Fig. 2. Yield of 'Classic' eggplant in 2015 (A) and 2016 (B) under increasing levels of flea beetle defoliation. Plants were transplanted in late May. One month after transplanting, all plants were treated with Voliam Express broadspectrum insecticide to eliminate any additional insect damage.

Efficacy of soil drench or foliar insecticides for flea beetle control

Vegetable growers have the option of applying systemic insecticides as a transplant drench for preventive control or applying a foliar spray insecticide if pest problems occur. For the former neonicotinoids are commonly used, particularly Admire Pro (imidacloprid). However, the neonicotinoid Venom (dinotefuran) is also registered as is the diamide insecticide Verimark (cyantraniliprole). The comparative residual efficacy among these products has not been thoroughly tested against flea beetles. Moreover, the residual efficacy of these insecticides compared with foliar spray applications has also not been thoroughly tested.

In 2015 we evaluated the efficacy of three soil-drench treatments: Admire Pro, Venom, and Verimark as well as four foliar spray treatments: Admire Pro, Venom, Exirel (same active ingredient as Verimark), and Brigade (bifenthrin). Field trials were conducted on both cabbage and eggplant planted in Whitethorne, VA. All insecticides tested provided effective kill of flea beetles at 1 wk post application on both crops (Tables 1 & 2). However, in the cabbage trial, by 23 days after soil application (June 13), Venom provided significantly better control than the other two soil insecticides, which essentially no longer provided any effective kill (Table 1). The pyrethroid Brigade (bifenthrin) performed the best among the four foliar treatments. Similar results were found in the eggplant trial, with Venom having the longest residual efficacy among soil insecticides, and Brigade performing the best among foliar treatments (Table 2).

Table 1. Flea beetle counts and yield of 'Bravo' cabbage treated with different soil-applied or foliar-applied insecticide treatments. Cabbage was transplanted 22 May 2015 at which time soil drenches were applied and foliar sprays were applied on 29 May.

			Mean # of flea beetles per 10 plants			Mean wt. (lbs.) of cabbage heads per plot
Treatment*	Rate per acre	Application Method	6/5	6/9	6/13	
Untreated Control	-	—	16.3a	35.0a	374.0b	23.0d
Admire Pro 4.6SC	7.3	Soil-drench	0.5b	33.8a	458.5ab	33.5cd
Venom 70SG	6.0	Soil-drench	1.5b	0.3d	11.3c	58.5a
Verimark 1.67SC	6.75	Soil-drench	2.0b	13.0bcd	558.0ab	40.8bc
Admire Pro 4.6SC	1.3	Foliar spray	0.8b	19.3ab	375.3ab	29.3cd
Venom 70SG	1.0	Foliar spray	1.0b	9.8bcd	633.0a	27.5cd
Exirel 0.83SOE	13.5	Foliar spray	0.0b	17.8abc	346.0b	32.0cd
Brigade	2.1	Foliar spray	2.0b	1.0cd	28.5c	54.3ab

* Admire Pro and Venom are neonicotinoids, Verimark and Exirel contain the same Diamide insecticide chlorantraniliprole (=cyazypyr), and Brigade is a pyrethroid.

Table 2. Flea beetle counts and yield of 'Classic' eggplant treated with different soil-applied or foliar-applied insecticide treatments. Eggplant was transplanted 22 May 2015 at which time soil drenches were applied and foliar sprays were applied on 29 May.

			Mean # of flea beetles per 10 plants			Mean # of eggplant per plot	
Treatment*	Rate per acre	Application Method	6/5	6/9	6/13	1st harvest	2nd harvest
Untreated Control	-	—	124.0a	99.3a	64.8b	7.8b	33.3b
Admire Pro 4.6SC	7.3	Soil-drench	9.0c	3.5b	29.0cd	12.3b	60.0a
Venom 70SG	6.0	Soil-drench	1.5c	1.8b	6.0d	29.8a	60.0a
Verimark 1.67SC	6.75	Soil-drench	31.3b	44.0b	65.3b	8.6b	56.0a
Admire Pro 4.6SC	1.3	Foliar spray	12.3c	23.5b	134.0a	9.7b	48.0ab
Venom 70SG	1.0	Foliar spray	5.5c	8.3b	62.3bc	7.0b	55.8a
Exirel 0.83SOE	13.5	Foliar spray	8.5c	29.5b	95.0b	9.2b	55.0a
Brigade	2.1	Foliar spray	1.5c	5.3b	10.5d	12.0b	61.8a

VEGETABLE CROP STAND ESTABLISHMENT

Lee Stivers
Penn State Extension, Washington County
100 West Beau St. #601, Washington, PA 15301
ljs32@psu.edu

One of the first and most critical steps in producing a high quality vegetable crop in the field is what we call "establishing a stand". Stand establishment means getting a crop off to a quick, healthy, and uniform start in the field. It also means using a planting arrangement that provides adequate room for plants to grow and develop, and one that makes it easy to manage the crop throughout the season. Weed control, pest control, fertilizer applications, irrigation, timing of harvest, and yield will all be influenced by the initial stand establishment.

In Pennsylvania, there are two main methods of establishing vegetable crops in a field: planting seeds directly into the soil or transplanting seedlings. Each method has advantages and disadvantages, depending on which vegetable crop is being grown. Vegetable crops that are most often direct seeded include sweet corn, beans, peas, carrots, pumpkins and winter squash. For many other vegetable crops, we usually transplant seedlings that have grown in the greenhouse. These include tomatoes, peppers, broccoli, cabbage, onion, lettuce, melons, cucumbers, and others.

Seeds and seedling biology: Choosing the right seed is an absolutely critical step in successful vegetable production. Seeds should be of high quality, clean, and purchased from a reputable seed company. Take care to choose varieties that are well adapted to the area, and to your customers. Purchase seed that is as free of disease as possible. Many of our vegetable disease problems, including diseases of tomato and pepper, can start in the greenhouse from infected seed. When infected transplants are planted in the field, these diseases can cause considerable crop loss later in the season. In some cases, hot water baths or chlorine rinses can be used to reduce diseases on the surface of seeds such as tomato, pepper, and cabbage. However, hot water treatments must follow strict time and temperature steps or seeds may be injured.

In transforming from a dormant seed to a growing plant, seeds first go through the process of germination. Seeds need the proper temperature, moisture, air, and light conditions to germinate. At optimal temperatures, germination is rapid and uniform. Good seed-to-soil contact is very important for germination. A fine-textured seedbed with little compaction is recommended for direct seeding in the field. For greenhouse transplants, soilless media should be moist and fluffy.

All seeds have optimal temperature ranges for germination. For example, lettuce and onion seeds germinate at lower temperatures than tomato or pepper. If temperatures are too low or too high, the seeds will not germinate, or will germinate very slowly. We can control these temperatures in the greenhouse. But for direct seeded crops, we need to make sure soil temperatures have warmed up enough for the crop before we plant the seeds. If soil temperatures are too cool, seeds will be very slow in germinating, and are more easily attacked by pests and diseases.

Growing healthy transplants. Producing quality transplants in a greenhouse requires healthy seed, a suitable potting mix or growing media, clean planting trays, fertilizer and water, and suitable temperatures.

A suitable potting mix (also called growing media) will support developing seedlings by providing air, nutrients, water, and a place for roots to grow. Most potting mixes are a mix of peat moss, vermiculite or perlite, and sometimes fertilizers or compost. Potting mixes can be purchased or mixed on the farm. Flats and trays used in the production of transplants should be new to avoid pathogens that cause disease problems. If flats and trays are reused, they should be thoroughly cleaned after use and disinfected using a chlorine solution or another suitable disinfectant, and dried thoroughly.

Lee Stivers has been a horticulture educator with Penn State Extension in Washington County since 2001. She is a member of Penn State Extension's Statewide Horticulture Extension Team, specializing in vegetables, small fruit and greenhouse production, as well as farm food safety and beginning farmers. Prior to moving to Pennsylvania, Lee worked for Cornell Cooperative Extension and the University of California, Davis, where she received her Masters degree in 1989.

Throughout seedling growth, keep the potting mix moist but not continually wet. Water less in cloudy weather, and try to water in the morning so that plant surfaces dry out before the end of the day. If you are growing plants in media without added fertilizer, you will need to water with added liquid fertilizer once the seedlings have emerged. Follow fertilizer recommendations for application rate (concentration) and frequency carefully. Use a fertilizer that is formulated specifically for greenhouse transplants; it should be completely soluble in water, and lower in P than N and K. Water quality is also an important consideration. Water used on seedlings should be tested to make sure it is in the optimal range for pH and alkalinity.

Once transplants have reached the appropriate size, they need to be hardened off before planting them in the field. To harden off seedlings, gradually expose them to conditions they will have in the field. Start by cutting back on water and fertilizer, then place transplant trays outside during the day for several days before planting.

Taking it to the field. Whether you are planting seeds directly into the field, or transplanting vegetable seedlings, your goal is to create as near optimum conditions as you can for each plant's first few days in the field. The goal is for seeds to start germinating rapidly, and for seedlings to suffer as little transplant shock as possible, as they move from seedling trays to the field.

Before planting seeds, it is important to prepare a good seedbed in the field. This will make planting easier and provide a better environment for seeds to germinate and emerge, especially for small-seeded crops such as carrots or lettuce. A proper seedbed is level and even, with no clods of soil or excess plant residue on the surface. Soil should be light and fluffy.

Seeds should have solid contact with moist soil so that they start the germination process soon after planting. Adjust seed depth to insure that seeds are placed in a zone with moisture, and that they are neither too shallow nor too deep for emerging from the soil. If field soil is light and fluffy, gently pack down the soil over the planted seed so that the seeds are in direct contact with the soil. Growers frequently add fertilizer to the soil before or at planting, with the fertilizer rate based on soil test recommendations. Make sure to place starter fertilizer at least two inches below and two inches to the side of where the seeds are being planted, to avoid damaging the germinating seed.

Seeds should be planted into moist soil, and the germinating seed and growing seedling will need water, either from the soil moisture, rainfall, or irrigation, during those early days of germination, emergence and growth. If the soil surface becomes dry, hard and crusty, tiny seedlings will not be able to emerge through the soil surface. Germinating seeds and young seedlings are also very susceptible to soil-borne diseases and insect pests. For this reason, many vegetable seeds are treated with fungicides and/or insecticides for early protection.

Most of the transplanted vegetables in Pennsylvania are grown using raised beds, plastic mulch, and drip irrigation. The plastic mulch suppresses weeds, and holds in moisture, while the drip irrigation places water just where plants need it—right in the root zone. Even so, transplants planted into the field will experience some level of transplant shock, because their roots have been disturbed from being pulled from the flat and pushed into soil in the field. It takes transplants a few days to adjust to their new growing environment. The goal is to minimize this transplant shock and get plants growing as soon as possible. Start with transplants that are hardened off, well watered before transplanting, and then supply more water during or immediately after transplanting.

Adding starter fertilizer to transplants is a little easier than for direct seeds. Because the transplants are bigger, they can tolerate having a fertilizer solution added right into the planting hole, right near their roots. Transplants are also susceptible to diseases and insect pests. Depending on the crop, some pest control steps might need to be taken right at transplanting. Plastic mulch helps with weed control in a transplanted field, but there will still be weeds between the mulch, and weeds in the planting holes, that need to be controlled.

Invest enough time, planning, and the right resources into establishing your vegetable crop stand; you'll be well on your way to growing and harvesting a productive and valuable vegetable crop!

References and Resources:

https://extension.psu.edu/seed-and-seedling-biology

https://extension.psu.edu/what-you-need-to-grow-healthy-transplants

https://extension.psu.edu/taking-it-to-the-field-seeding-and-transplanting-vegetables

SUPPORTING BEE POPULATIONS FOR CUCURBIT CROPS

Shelby J. Fleischer, Erin Treanore, Carley McGrady, Department of Entomology
The Pennsylvania State University, University Park, PA 16802

Among the objectives in the Integrated Crop Pollination (ICP) Project (www.icpbees.org) were measures of the species composition and visitation rate of bees in commercial tree fruit, blueberries, and cucurbits. Resources for growers are at http://icpbees.org/tools-for-growers/. Earlier summaries, including a 2015 Proceedings article for this Convention – are relevant and reproduced here. Additional results using genetics to measure wild colony abundance, and work with cover crop mixtures are at http://icpbees.org/wp-content/uploads/2014/05/Integrated-Crop-Pollination-for-Cucurbita-crops.pdf (Ullmann et al. 2017) and portions reproduced here.

Cucurbits crops include 4 genera: (i) squash/pumpkin, (ii) cantaloupe/muskmelon, (iii) cucumber, and (iv) watermelon. Most require movement of large, sticky pollen grains to set quality fruit. In cucumber, a few cultivars set fruit without pollination. Bees pollinate cucurbit crops, but the species that do the job varies among crops, landscapes, and geographic region. In cantaloupe/muskmelon, cucumbers, and watermelon, in addition to honey bees, multiple wild species contribute important pollination services [28 in cucumber in Indiana (Smith 2013); wild bees provided full pollination in ~90% of small, diversified farms in NJ and eastern PA (Winfree et al 207a, b)]. The presence of both honey bees and wild bees ensured resiliency in pollination services. In the squash/pumpkin, although we recorded about 30 species visiting pumpkin flowers, the overwhelming majority of the pollination services come from two wild species: the squash bee (*Peponapis pruinosa*) and one species of bumble bee, the common eastern bumble bee (*Bombus impatiens*). This has also been seen in NY (Artz and Nault 2011, Artz et al 2011, Petersen et al 2013), MA (Alder and Hazzard 2009), and VA (Shuler et al 2005, Julier and Roulston 2009).

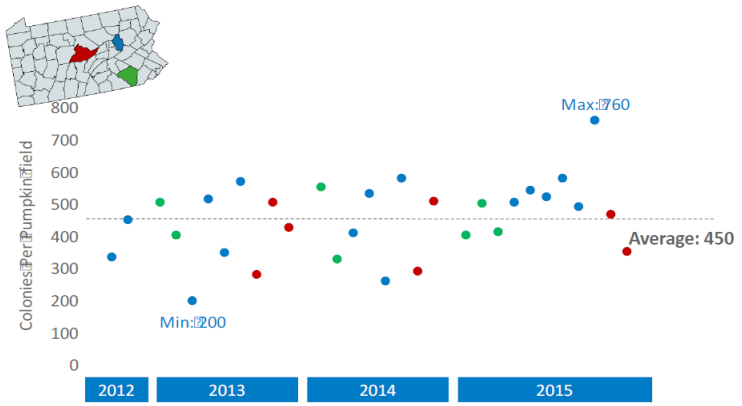
The squash bee is a specialist - it requires pollen from squash/pumpkin to rear its larvae. It is a solitary bee, which nest and overwinters in the soil. It emerges in late June or early July. Having squash flowers present may help ensure colonization. Although you may find adults occasionally taking nectar from other plant species, the overwhelming majority of plant species in which you find squash bees is in squash flowers. Ensuring these crops are in the landscape is important to building populations over time, and some have suggested early-planting of Cucurbita. Landscapes with no-till had higher populations of squash bees (Shuler et al 2005). Grassy areas, and exposed soil, could serve as nesting sites. Sufficient soil moisture may help with nesting (Julier and Roulston 2005).

The common eastern bumble bee is a generalist so diverse and continuous floral resources are important. Overwintered queens are establishing nests in late March, April, and May. Queens are finding and building nests, laying eggs, keeping the brood warm with body heat, provisioning brood with pollen sometimes mixed with nectar, and rearing the first generation of brood. She needs plentiful, diverse, and high quality floral resources in proximity to her nest. With Erin Treanore, we used a mixture of 'Witchita' canola, 'Dixie' crimson clover, 'Purple Bounty' hairy vetch, and oats as a nurse crop, planted in September of the previous year and allowed to flower in the spring, to provide floral resources during this time. The oats winter-killed in most years, and thus did not compete with the flowering species in the spring. During mid-summer, cucurbit crops acts as a floral resource it is mostly a nectar, not a pollen resource, for bumble bees. Non-crop plants may be important to supplement this or provide pollen resources, but they also might compete for bumble bee visits. For example, bumble bees will visit thistle and solanaceous weeds, and not pumpkin, if these weed are flowering in your field. As summer comes to a close, female offspring become reproductive, males are produced, mating occurs, and mated females ('gynes') will attempt to overwinter. A mix of buckwheat, 'Perodovik' sunflower, and 'Braco' white mustard, planted in July (following wheat) would flower during the time gynes are acquiring resources for overwintering. Buckwheat and sunflowers, planted in midsummer, are

Dr. Fleischer is on the faculty of the Department of Entomology at The Pennsylvania State University where he specializes in population dynamics of insects. He has been worked in vegetable agroecosystems for over 25 years. He previously was a Research Scientist at Virgina Tech and Research Associate at Auburn University. He received his B.S. in Biology from St. Mary's College of Maryland, his M.S. in Entomology from Virgina Tech and his Ph.D. in Entomology from Auburn. A native of Washington, D.C., he and his wife Barbara have two daughters and three grandchildren.

flowering in late August and into September, and are visited by the common eastern bumble bee. The mustard was utilized more heavily by honey bees. There are also a very wide range of perennial and weedy species visited by bumble bees.

As part of Project ICP, Carley McGrady optimized a genetic method that allowed us to estimate the number of common eastern bumble bee colonies that send foragers into commercial pumpkin, by counting 'sisterhoods'. We measured approximately 450 colonies sending foragers into commercial fields. Additional genetic analyses showed lots of genetic variation and mixing for this species, which are good signs for a resilient population.



Each point represents the number of bumble bee colonies visiting a pumpkin field. The number of colonies is along the y-axis. Our results show a minimum of 200 colonies visiting a single field and a maximum of 760. The overall average was 450 colonies per field, represented by the horizontal dotted line. The points are arranged along the x-axis by year, starting with 2012 and ending with 2015. Blue dots indicate fields from Columbia County, green dots indicate Lancaster County and red dots indicate Centre County.

Conservation with IPM. Our bumble bee and squash bee numbers, and studies from neighboring states, represent an amazing and valuable abundance of wild bees that are strongly contributing to the valuable ecosystem service of pollination. Create farmscape and landscapes that provide abundant floral resources in proximity to good nesting sites. Balancing crop protection needs with efforts to sustain pollinators is difficult. Limiting neonicotinoids to seed-treatments minimizes the residues that show up in nectar and pollen. Avoid neonicotinoids in watermelon: they do not need protection from cucumber beetles. Squash/pumpkin flowers close by mid-day, so limiting all foliar sprays to after the flowers have closed, is certainly helpful. For the other crops, spraying as late in the day, or at night, minimizes the residue on the flowers that the bees could contact the next day. Only spraying when scouting indicates the need helps, and for aphids and mites, using the selective aphicides and miticides can reduce the risk to bees. Be aware that some fungicides enhance the toxicity of some insecticides to bees. **The 2018 Commercial Vegetable Production Guide has revised the pollinator section**. Growers should become familiar with EPA's new pollinator protection labeling guidelines and bee advisory box at: *https://www.epa.gov/pollinator-protection/new-labeling-neonicotinoid-pesticides*.

Alder, L. S., and R. V. Hazzard. 2009. Comparison of Perimeter Trap Crop Varieties: Effects on Herbivory,Pollination, and Yield in Butternut Squash. Environ. Entomol. 38(1): 207- 215

Artz, D. R., C. L. Hsu & B. A. Nault. 2011. Influence of Honey Bee, *Apis mellifera*, Hives and Field Size on Foraging Activity of Native Bee Species in Pumpkin Fields. Environ. Entomol. 40: 1144-1158

Artz,D. R., & B. A. Nault. 2011. Performance of *Apis mellifera*, *Bombus impatiens*, and *Peponapis pruinosa* (Hymenoptera: Apidae) as Pollinators of Pumpkin. J. Econ. Entomol. 104(4): 1153-1161

Julier HE, Roulston TH. 2009. Wild bee abundance and pollination service in cultivated pumpkins: farm management, nesting behavior and landscape effects. J. Econ. Entomol. 102: 563-573.

Petersen JD, Reiners S, Nault BA. 2013. Pollination Servies Provided by Bees in Pumpkin Fields Supplemented with Either Apis mellifera or Bombus impatiens or Not Supplemented. PLoS ONE 8(7): e69819. doi:10.1371/journal.pone.0069819

Shuler RE, Roulston TH, Farris GE. 2005. Farming practices influence wild pollinator populations on squash and pumpkin. J. Econ. Entomol. 98: 790-795.

Treanore, E. 2017. Supporting *Bombus* and other bees in *Cucurbita* agroecosystems. MS Thesis, Pennsylvania State University

Smith, Bentley, Reynolds. 2013. Wild bees visiting cucumber on midwestern U.S. organic farms benefit from near-farm semi-natural areas. JEE. 106: 97-106.

Ullmann, K., Cane, J., Fleischer S., Treanore, E., McGrady, C. 2017. Integrated crop pollination for squashes, pumpkins, and gourds. Project Integrated Crop Pollination. ProjectICP.org http://ento.psu.edu/publications/integrated-crop-pollination-for-squashes-pumpkins-and-gourds and http://icpbees.org/wp-content/uploads/2014/05/Integrated-Crop-Pollination-for-Cucurbita-crops.pdf

Winfree, R., N. M. Williams, J. Dushoff, and C. Kremen. Kremen. 2007a. Native bees provide insurance against ongoing honey bee losses. Ecology Letters 10: 1105–1113

Winfree, Rachael, Neal M. Williams, Hannah Gaines, John S. Ascher, and Claire Kremen. 2007b. Wild bee pollinators provide the majority of crop visitation across land-use gradients in New Jersey and Pennsylvania, USA Journal of Applied Ecology

BASICS OF DRIP IRRIGATION FOR VEGETABLE AND SMALL FRUIT

William James Lamont Jr.
Professor Emeritus,
Department of Plant Science
The Pennsylvania State University
University Park, PA 16802
E-mail: wlamont@psu.edu

Drip Irrigation

Drip (trickle) irrigation was pioneered in the 1940s in England, but not until the advent of polyethylene plastics in the 1960s did field application of this efficient watering method become widespread. Drip irrigation is a method of applying small amounts of water, often on a daily basis, to the plant's root zone. A drip irrigation system has four major components and two options.

Major Components

- Delivery system: pumps, main line, sub main line, manifold or header line, drip tape or tubes
- Filters: sand, disc, or screen
- Regulators: for maintaining the proper pressure in the system
- Valves and Gauges: a wide assortment of zone, check or pressure gauges or valves

Options

- Controller: simple electric clock or computer
- Fertigation system: electric pumps, hydraulic pumps, venturi systems, etc.

How you put these components together and which options you choose will depend on the size of the system, the water source, the crop, and the degree of sophistication you desire. A portable system can be developed that includes the pump, gasoline engine, filters, fertilizer injector all contained on a trailer unit that can be moved from water source to water source or field to field.

Because vegetables and small fruits are usually planted in rows, drip tubing with prepunched emitter holes, called a line source emitter, is used to wet a continuous strip along the row. Also, because most vegetables are considered annuals and are grown for only one season, a thin-walled disposable tubing (4 or 8 mil thick) generally is used for only one season. Less emphasis usually is placed on buried mainlines and submainlines to allow the system to be dismantled and moved from season to season. Costs may be high, so a goal should be to develop an inexpensive yet functional system that allows maximum production with minimal costs. You can purchase an entire system from an irrigation dealer or adapt your own components. I would strongly recommend that one get assistance in design of their system from an irrigation dealer or professional since it might be very helpful in avoiding problems later.

Dr. William J. Lamont Jr. is a Professor and Extension Vegetable Crops Specialist in the Department of Plant Science at Penn State University. He was born and raised in rural Pennsylvania and obtained two undergraduate degrees, one in Economics and Business from Lebanon Valley College and one in Horticulture from Delaware Valley College. He earned his M.S. and Ph.D. degrees from Cornell University. Dr. Lamont has an extensive background in research, extension and teaching. In his current extension position Dr. Lamont is responsible for the culture and management of vegetable crops. He has worked at North Carolina State University and Kansas State University prior to coming to Penn State in 1997. He and his wife Phyllis reside on 28 acres of land between Pine Grove Mills and McAlevy's Fort, PA.

Delivery System

Mainline distribution to the field: Underground plastic or PVC pipe or aboveground aluminum or plastic pipe can be used to deliver water from its source (pump, filtering system, etc.) to the sub-mainline (header line). Any PVC exposed to sunlight should be painted black to prevent the growth of algae inside the pipe.

Submainline (header): A vinyl "lay flat" hose or plastic pipe commonly is used as the sub-mainline (header line). The hose is durable, long-lasting, and lays flat when not in use, so equipment can be driven over it. The plastic pipe may be a little more difficult to roll up. The lay flat hose, plastic pipe, and plastic connectors are retrieved after each growing season, cleaned, and stored until the following year.

Plastic Connectors: Water flows to the drip tubing through small plastic loc sleeve fittings connecting the sub-mainline (header line) and each drip tube. Connectors can be inserted directly into the vinyl hose or plastic pipe. Self-flushing end caps also can be attached to the end of the drip tape.

Drip tape or tube: Drip irrigation tape is on a reel and is applied just in front of the plastic mulch roll. For single-row crops such as tomatoes, cucumbers, and melons, the tube should be placed 4-5 inches off-center and 2-4 inches deep, with the emitter holes facing upward. The shank that directs the drip irrigation tape into the soil can be adjusted to any position or depth desired. With double-row crops, such as okra, eggplant and peppers, the tape should be placed in the center of the bed at the same depth. Allow enough drip irrigation tape so as to extend at least 2 feet past the end of the plastic mulch. This end will be an indicator of plugging of the drip irrigation tape when the system is running and serve as a flush-out point during maintenance of the system. A roll of drip tape usually is about 7500 feet long, depending on the thickness, which normally is 8 mil and the manufacturer. Most tape is polyethylene black plastic, 4 to 8 mil thick, with holes at intervals of 4 to 24 inches (12 inch is the most common) that emit water at about .22-.45 gallons per 100 feet per minute when operated at 8 psi pressure. On 5-foot centers, there are 8,712 linear feet of row per acre, thus a grower thus should plan on using about 1.25 rolls of drip tape per acre. On 6-foot centers, 1 roll of drip tape would be needed. An example of a 20-acre plastic mulch/drip irrigation system is presented in Table 2.

Filters

Filters are essential to the operation of a drip system and may be viewed as the most important component of a drip system. For wells or municipal water, a screen filter or disc filter can be used. Screen filters (150–200 mesh screen) are available in sizes from 3/4 inch (used only for 1/2 acre) to 6 inches (used with several acres). Some filters have a valve to open and flush them. Disc filters operate with a series of discs stacked vertically to separate out small particles. Although more expensive to purchase, they are reliable and easy to clean.

For any open or surface water sources, sand filters are absolute necessities. They are installed as pairs of sand-filled canisters and can be back-flushed to accomplish cleaning. Canisters from 14 inches (enough for 2 acres) to 48 inches in diameter are used, depending on the size of the system. They can be assembled in a series (4,6,8,10 units) to allow more area to be irrigated at one time.

The need to clean or flush filters can be determined by the loss of pressure through the filter. You can install pressure gauges on either side of the filter to indicate the need to flush when pressure loss exceeds 5 to 7 psi. With only one pressure gauge behind the filter, watch for reduced operating pressure in normal operation. When stream or river water is used, a sand separator usually is needed to remove suspended sand from the water before it enters the sand filter.

Pressure Regulators

Most drip tubing is designed to operate at 8 to 15 psi pressure, with 10 psi being standard operating pressure. A spring-type (used on smaller systems) or diaphragm-type pressure regulator can be purchased to hold pressure steady. These are inexpensive and reliable. Both adjustable and preset types are available.

Valves or Gauges

Watering several fields or sections of fields from one water source can be accomplished by a zone system using valves to open and close various lines. A backflow/antisiphon valve is a necessity on a well or municipal source, where fertilizers or chemicals are to be injected into the line. Hand-operated gate or ball valves or electric solenoid valves can be used to automate the system using a time clock, water need sensor (discussed later), or automatic controller box ("computer" controller).

Optional Additions for Fertigation or Chemigation

Soluble fertilizers can be added to the drip irrigation water to provide uniform crop fertilization. Venturi units are available in sizes up to 2 inches in diameter. More expensive injectors with greater capacity and accuracy use electric or hydraulic "pumps" to inject fertilizer solutions from a stock tank into the line. A hydraulic device, called a Dosatron, placed in the mainline can be set at various dilution rates and operates with water flowing directly through it. Use only high quality, soluble fertilizers that completely dissolve. All fertilizer injections should be made ahead of either the main filters in the line or ahead of secondary filters if placed closer to the field, so that any contaminants are filtered out.

Water Quality

Water for drip irrigation can come from wells, ponds, rivers, lakes, municipal water systems, or plastic-lined pits. Water from these various sources will have large differences in quality. Well water and municipal water is generally clean and may require only a screen or disc filter to remove particles. However, no matter how clean the water looks, a water analysis/quality test prior to considering installation of a drip irrigation system should be completed to determine if precipitates or other contaminants are in the water. This water quality analysis should identify inorganic solids such as sand and silt; organic solids such as algae, bacteria, and slime; dissolved solids such as iron, sulphur, and calcium; and pH of the water.

Table 1: Criteria for Plugging Potential of Drip Irrigation System Water Sources

	Plugging Hazard		
Factor	Slight	Moderate	Severe
	[in parts per million (ppm)* except pH]		
Physical			
Suspended Solids (filterable)	<50	50-100	>100
Chemical			
pH	<7.0	7.0-7.5	>7.5
Manganese	<0.1	0.1-1.5	>1.5
Iron	<0.1	0.1-1.5	>1.5
Hardness	<150	150-300	>300
Hydrogen sulfide	<0.5	0.5-2.0	>2.0

*Some water reports list results as milligrams per liter - mg/L which is equal to parts per million-ppm

Measurement of Amount of Water Applied

Drip irrigation is, in many ways, a different way of irrigating. The goal should be to achieve a high level of efficiency and maximum yield of produce from a minimal amount of water.

It is important to be able to determine the flow rate of the system and the total amount of water used by the system at any given point during the growing season. Thus a water meter is a critical component of any drip irrigation system and will provide a warning of flow problems in the system, either restricted or excessive flow of water in system. The water meter is your eyes and ears on the system. Knowing your actual flow rate as against the projected flow rate based on the system design is a valuable piece of knowledge and is used in many calculations.

Tensiometers are used to directly measure soil moisture. Tensiometers usually are installed in pairs, called a "station". One instrument should be placed in the zone of most active root uptake. They are installed in the crop row where the majority of the plant roots are located. Shallow tensiometers indicate the moisture status of the active root zones; the deeper ones tell you whether the amount of water applied is correct. Tensiometer can be purchased with solenoid switches to allow complete automation of the irrigation process.

Table 2. Components list for 20-acre plasticulture system.

Component Description	Quantity	Type Unit	Unit Price	Total Price
Engine and pump (14HP engine and Berkley pump)	1	Ls	$4,000.00	$4,000.00
24" media filter and fertilizer injector		Pr	$3,200.00	$3,200.00
Layflat - 4"	1800	ft.	$1.01	$1,818.00
Layflat - 3"	1500	ft.	$0.81	$1,215.00
Drip tape (7500'/Roll)	20	ea.	$135.00	$2,700.00
Plastic mulch (1.0 mil black embossed 4,000'/Roll)	40	Rl	$80.00	$3,200.00
Zone control/PRV valve - 3"	4	ea.	$180.00	$720.00
Insert tee - 4"	1	ea.	$31.62	$31.62
PVC tee (SxT) - 4" x 3"	4	ea.	$14.34	$57.36
Insert ELL - 4"	2	ea.	$21.25	$42.50
Insert x slip adapter - 4"	6	ea.	$11.26	$67.56
PVC bush. - 4" x 2"	2	ea.	$5.35	$10.70
PVC tee (SxT) - 3"	4	ea.	$10.87	$43.48
PVC nipple - 3" x 4"	8	ea.	$5.52	$44.16
Insert x slip adapter - 3"	8	ea.	$8.92	$71.36
Insert male adapter - 3"	8	ea.	$5.30	$42.40
PVC ELL (SxT) - 3"	8	ea.	$6.80	$54.40
PVC bush. - 3" x 2"	8	ea.	$2.28	$18.24
PVC nipple - 2" x 4"	10	ea.	$1.49	$14.90
Air release valve - 2"	10	ea.	$27.00	$270.00
PVC ELL - 2"	2	ea.	$1.38	$2.76
Hose clamp - 4"	14	ea.	$1.72	$24.08
Hose clamp - 3"	16	ea.	$1.47	$23.52
Tape x layflat connectors	480	ea.	$0.95	$456.00
Layflat hole punch	2	ea.	$75.00	$150.00
			SUBTOTAL	$18,278.04
			TAX 1%	$182.78
			TOTAL	$18,460.82

Note: Other equipment to be considered includes: secondary filters, additional pressure gauges, water meter.

TILLAGE AND COVER CROPS IN SNAP BEAN/PEA PRODUCTION

Gordon Johnson, Univ. of Delaware

The University of Delaware is the main institution in the Mid-Atlantic region conducting research on processing vegetable crops due to the historically large acreage in the state. The goal of this project was to provide a research base to enhance processing vegetable production in DE. Research was conducted on crop culture for yield and quality improvement and cost reduction in production for major processing crops including lima beans, sweet corn, peas, and snap beans.

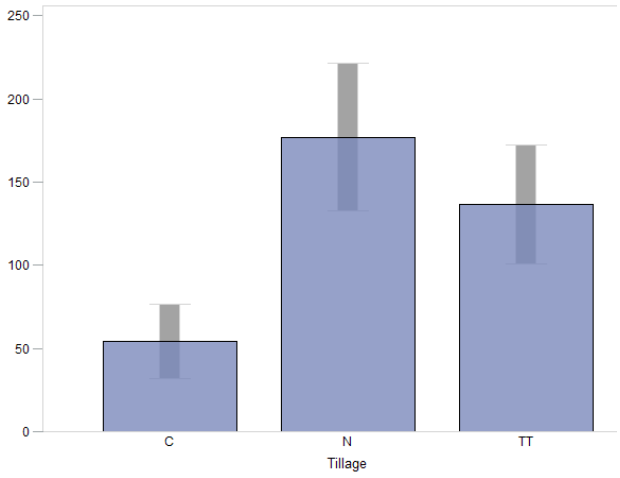
There are 31,000 acres of processing vegetables grown in Delaware with a value of $20 million dollars. The majority of processing acreage is in baby lima beans, sweet corn, green peas, snap beans and pickling cucumbers. There are over 100 farms in Delaware that contract with regional processors and more than 60 growers on the nearby Eastern Shore of Maryland that receive processing crop information from the University of Delaware vegetable research program. The UD vegetable research program interacts with 7 regional processors that source vegetables from Delaware. Maintenance of current acreage is critical for processor retention. Improved productivity and yield stability is sought by processors to reduce sourcing costs and costs associated with plant scheduling. This research was aimed at improving supplies from a yield stability and quality perspective for processors, reducing costs for processors and growers, and improving profitability of both processors and growers.

Pea Tillage Studies With Radish and Mustard Cover Crops for Compaction Mitigation

In 2012, a small plot trial with eight winter killed cover crop species was conducted and peas were no-tilled into the plots in March. Cover crop biomass, pea stand, pea yield and pea quality data was taken. In addition, a large plot pea study was conducted in a field where forage radishes were planted. The trial had three treatments – conventional tillage, vertical tillage, and no-till in the spring following the forage radish cover. Stand, biomass, yield, and quality data was collected. Results showed that forage radish, oilseed radish, and Kodiak mustard cover crop treatments provided the best yields in the following pea crop. Tillage studies showed that no-till peas into winter killed forage radish may be a viable option for growers and had better yields than conventional treatments.

In 2013 the trials were repeated. A small plot trial with eight winter killed cover crop species was conducted and peas were no-tilled into the plots in March. Cover crop biomass, pea stand, pea yield and pea quality data was taken. In addition, a large plot pea study was conducted in a field where forage radishes were planted. The trial had three treatments – conventional tillage, vertical tillage, and no-till in the spring following the forage radish cover. Stand, biomass, yield, compaction, and quality data was collected. In 2014 there was an additional trial with peas planted after winter killed forage radish. These studies also showed that peas were successfully no-till planted after forage radish. However, stand counts were lower in both no-till and vertical tillage plots and compaction was lower in conventional plots in 2014. Forage radish did not reduce compaction significantly in the 2014 study.

Compaction in peas by tillage (psi force) at 4" 2014



Dr. Gordon Johnson is the Extension Vegetable and Fruit Specialist at the University of Delaware stationed at the Carvel Research and Education Center near Georgetown, DE. He conducts applied research and provides extension programming in vegetable, fruit, and specialty horticulture crops. He has his B.S., degree in Agronomy from the University of Maryland, M.S. degree in Horticulture from Clemson University and his Ph.D. in Plant Science from the University of Delaware. A native of Gettysburg, PA he and his wife Yacintha reside in Denton, MD.

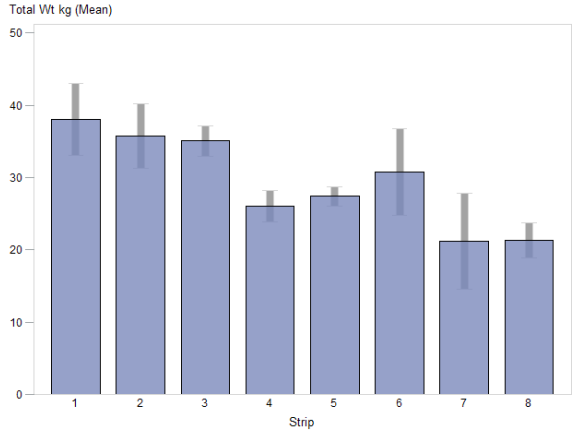
Tillage Trials

Studies were initiated in 2012 looking at tillage practices in three processing vegetable crops. This included a pea study planted into winter killed forage radish under three tillage practices (no-till, vertical tillage, and conventional tillage), a processing sweet corn study planted after winter cover crops under the same three tillage practices, and a lima bean study planted after small grain under the same three tillage practices. Results indicated that peas are successfully no-tilled, early processing sweet corn performed best under conventional tillage and lima beans performed best under conventional tillage.

Studies were conducted in 2013 and included pea, sweet corn, and snap bean studies planted into winter killed forage radish under three tillage practices (no-till, vertical tillage, and conventional tillage) and lima bean, snap bean, and sweet corn planted after wheat under four tillage practices (no-till, strip till, vertical tillage, and conventional tillage). In these studies there was no yield reduction with no-till in peas, sweet corn or snap beans in spring studies planted after forage radish. Summer studies planted after wheat showed no difference between tillage treatments in any crop.

Studies were repeated in 2014 and included pea, sweet corn, and snap bean planted into winter killed forage radish under three tillage practices (no-till, vertical tillage, and conventional tillage) and lima bean, snap bean, and sweet corn planted after wheat under 4 tillage practices (no-till, strip till, vertical tillage, and conventional tillage). There was no yield reduction with no-till in peas or snap beans in spring studies planted after forage radish. Summer studies planted after wheat showed reduced yields in lima beans in no-till and vertical tillage treatments; no-till plots had significantly lower yields in the snap beans and sweet corn; and vertical tillage and strip tillage performed similarly to conventional tillage in snap beans and sweet corn.

Spring snap bean tillage trials 2014. Strips 4 and 7 are no-till. Conventional tillage are strips 3 and 6.



Over all years, studies showed that peas can be successfully no-tilled into forage radish and mustard cover crops without a yield decrease or change in maturity. However, there was also no advantage in yields. Compaction was not reduced in no-till plots when compared to no-till into forage radish with the exception of wheel tracks. An advantage to the no-till pea/forage radish winter killed forage crop was the reduced trips across the field and reduced field tracking. This work gave enough evidence to recommend the practice to growers on a trial basis. Sweet corn and snap bean are more variable following forage radish due to the potential for stand losses when using no-till. Vertical tillage performed equal to the conventional tillage in these trials and can be recommended.

For no-till after small grain, results were also more variable. Sweet corn performed equally well in row cleaner and vertical tillage methods but not consistently in no-till. Lima beans cannot be recommended to be no-tilled at this time due to potential yield losses as shown in 2 of 3 years of the studies. No-till produced variable results in snap beans and warrants additional study whereas vertical tillage and strip tillage produced equivalent results when compared to conventioanl tillage.

MILDEW MANAGEMENT IN CUCURBITS

Beth K. Gugino
Department of Plant Pathology and Environmental Microbiology,
The Pennsylvania State University
219 Buckhout Lab, University Park, PA 16802
bkgugino@psu.edu

Powdery and downy mildews continue to be an annual concern in cucurbit production. Since neither of the pathogens overwinter in the Northeast and mid-Atlantic regions, the pathogens move into our production fields from other nearby sources typically moving from the southeast up along the east coast or in some cases from more northern sources.

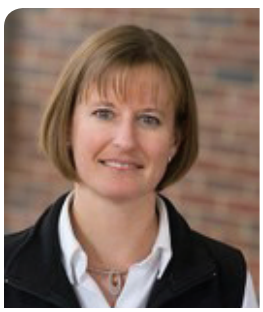
Powdery Mildew (caused primarily by *Podosphaera xanthii*)

When it comes to cucurbit diseases powdery mildew is unusual because disease development can be initiated at a lower relative humidity (~50% RH) and leaf dryness (over leaf wetness) favors colonization, sporulation and dispersal of pathogen spores. Temperatures between 68 and 80°F are most favorable for disease development.

The **first signs of powdery mildew** are small white powdery spots most commonly seen on the underside of the leaves or within the plant canopy. When scouting, it is important to thoroughly look over the entire plant. Also scout by cultivar to account for differences in host resistance; usually scouting the most susceptible cultivars first around the time of fruiting. If protectant fungicides are being used, sometimes the spots on the upper leaf surface are yellow or chlorotic with white powdery lesions on the corresponding underside of the leaf. Accurate diagnosis is critical because targeted conventional fungicides applied for managing powdery mildew are different than those used for downy mildew.

Host resistance is an important tool for disease management and fortunately, there is a wide array of cucurbits that have been conventionally bred with resistance. Genetic resistance can often both delay the onset of powdery mildew and reduce overall disease severity. As a result, it is important to scout for powdery mildew by cultivar. See the 2018 Mid-Atlantic Commercial Vegetable Production Recommendations for an updated list of cultivars recommended for our production region that have resistance. From these lists the majority of recommended cucumber and muskmelon cultivars have resistance. Pumpkin cultivars designated with PMR (i.e. WeeeeOne and Magician) indicate powdery mildew resistant and obtained a copy of the resistance allele from each parent versus those designated PMT (i.e. Iron Man and Magic Lantern) which indicates tolerance and contain only one resistance allele from one parent. For pumpkins, the resistance is most effective when it is from both parents (homozygous resistance) compared to one parent (heterozygous resistance). Less resistance is available in summer squash cultivars.

When powdery mildew occurs early in the season and is left unmanaged it can severely reduce the photosynthetic area of the leaves needed to produce high quality marketable fruit. On pumpkin later in the season, it can also severely damage the handles leaving them weak further reducing marketability. **Fungicides are another important tool** for managing powdery mildew in-season however, there is considerable concern over the development of fun-



Beth K. Gugino is an Associate Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University located at University Park, PA. Her extension and research program focuses on the identification, epidemiology and management of vegetable diseases important to the Pennsylvania and the Northeast region. She received her B.S. in Horticulture and M.S. and Ph.D. in Plant Pathology from The Pennsylvania State University. She was a post-doc at the New York State Agricultural Experiment Station with Cornell University working with diseases of vegetable crops and soil health for four years before returning to Penn State in June 2008.

gicide resistance among the single mode-of-action or targeted conventional fungicides. For resistance management, it is recommended that the most effective products are applied when symptoms are first observed (one powdery mildew spot on 45 to 50 leaves) and then later in the season when switch to a protectant spray program rather than the reverse. In the long-run this will reduce the selection pressure for powdery mildew spores that are resistant to the fungicide because fewer spores are exposed to the active ingredient when disease severity is low.

Annually since 2009, pumpkin powdery mildew fungicide trials have been conducted on a susceptible pumpkin cultivar such as Sorcerer and Howden at the Russell E. Larson Research and Education Center in Centre Co., PA. Products that continue to be the most effective include Torino 0.85SC (FRAC code U6), Vivando 2.5SC (U8), Luna Experience 3.34SC (3 + 7) and Quintec 2.08SC (13). These are best used when alternated with products like Fontelis 1.67SC (7), Procure 480SC (3), tebuconazole (3), Inspire Super 2.8F (3 + 9), Pristine 40WSP (11 + 7), Aprovia Top 1.62EC (3 + 11) and Rally 40WSP (3) or with micronized wettable sulfur 80W (M2). Each application should be applied tank mixed with a broad spectrum protectant fungicide to manage for fungicide resistance and always rotate between FRAC codes with each application.

Due to increasing **concerns about pollinator health** and their exposure to fungicides such as chlorothalonil when possible, time fungicide applications when fewer pollinators are foraging and visiting flowers and flowers are closed. In trials conducted over the past couple of years to identify alternatives to tank mixing with chlorothalonil, both Tritek (mineral oil) and Microthiol Disperss (sulfur) were determined to be equally effective tank mix partners and pose less of a risk to bee health.

Fortunately, cucurbit powdery mildew is one of the easier diseases to **manage organically** and there are a number of options including copper, sulfur, oil-based products like Eco E-rase (jojoba oil), JMS Stylet oil (paraffinic oil), Trilogy (neem oil) and Organocide (sesame oil), as well as potassium bicarbonate-based products such as Kaligreen and MilStop to name a few. With these products, spray coverage is essential since they are only effective at the site of application. So apply them in a large enough volume of water at a higher pressure to move the spray and penetrate the plant canopy.

Downy Mildew (caused by *Pseudoperonspora cubensis*)

Cucurbits differ in their **susceptibility to cucurbit downy mildew** in part due to the development of pathotypes within the pathogen population which differ in their ability to infect cucurbit hosts. Cucumber and muskmelon are susceptible to all five described pathotypes while pumpkin and winter squash are only susceptible to a single pathotype. Often the pumpkin/winter squash specific pathotype is not prevalent in the region until later in the growing season and sometimes after the fruit have reached maturity. Since downy mildew does not directly affect the fruit, as harvest gets closer, managing this disease becomes less important unless you have succession plantings. In the latter case, managing this disease through harvest is important and then burning down or disking under the crop residue is important to minimize spread to the younger plantings.

Downy mildew lesions are most easy to recognize on cucumber. The small angular lesions delineated by the leaf veins are initially pale green before turning yellow in color. On the underside of the leaf, the spots look water soaked at first and under high relative humidity the lesions will sporulate giving them a purplish gray color. On muskmelon, the lesions are slightly more irregular in shape but will still be delineated by the leaf veins. In all cases as the dew dries, purplish-gray sporulation can be observed. Downy mildew can easily be confused with the bacterial diseases angular leaf spot or bacterial leaf spot, both of which are common problems in different types of cucurbits. To distinguish downy mildew, look for the purplish-gray sporulation on the underside of the leaf. If you do not see downy mildew sporulation in the field (most obvious in the morning as the dew dries), place several symptomatic leaves in a sealed bag overnight and then check for the sporulation the next day. Sporulation can sometimes be sparse if the field is being managed for other diseases using protectant fungicides which also have some efficacy on downy mildew. Under favorable conditions as the disease progresses and lesion coalesce, the leaves can turn upward making them appear scorched.

Since downy mildew does not survive overwinter in our region and it is not always a problem on all the cucurbit types each year**, downy mildew forecasting** becomes an important tool for helping time fungicide applications. Disease forecasting (http://cdm.ipmpipe.org) can be used to predict the movement of downy mildew spores along the east coast by using the forecasted wind trajectories from infected fields (i.e. sources of the pathogen). The risk of downy mildew developing is based on the 1) severity of disease at each known source, 2) how favorable the weather conditions are for spores to be moved from these sources, 3) likelihood that spores will be protected by clouds from sunlight and remain viable in the wind current and 4) how favorable conditions might be for infection in the field where the spores could be deposited/land. If an area is considered high risk, then conditions are favorable for spore dispersal, movement, deposition and infection in susceptible crops along that wind trajectory. If an area is considered low risk, the weather may be favorable for spore dispersal from infected fields, but unfavorable for their transport and deposition onto susceptible crops or vice versa.

During the season, information regarding regional cucurbit downy mildew outbreaks and forecasting in PA and the surrounding region is disseminated in updates and alerts from Penn State Extension (https://extension.psu.edu/forage-and-food-crops/vegetables) as well as from the Pennsylvania Vegetable Marketing and Research Program (both electronically and in hardcopy). In addition, monitoring and forecasting maps are being updated at 12 produce auctions across PA and a voicemail message update can be accessed via the 1-800-PENN-IPM hotline during the growing season.

Fungicides are an important tool for downy mildew management and are very effective if well timed. Preventative applications when downy mildew has been confirmed on a particular cucurbit host in the region and/or the risk of infection and disease development is high will be more effective than those made after the disease is observed in the field. Similar late blight, under favorable conditions this disease can defoliate a crop in as few as 7 to 10 days under favorable conditions.

There are a number of **fungicides** that are very effective for managing downy mildew when there application is timed correctly (preventatively). Some of these products include Orondis Ultra (U15 + 40), Orondis Opti (U15 + M5) and Ranman 400SC (21) rotated with Previcur Flex 6F (28), Zampro 525SC (40 + 45), Zing! 4.9SC (M5+ 22). Contact protectant fungicides being applied for the management of powdery mildew can also help manage downy mildew. Incorporating downy mildew target fungicides only when necessary can help to reduce input costs. See the 2018 Mid-Atlantic Commercial Vegetable Production Recommendations for a more complete list of recommended products. For resistance management, rotate between FRAC code groups and tank mix with protectant fungicide. In fall 2017, Valent received a federal registration for Elumin (ethaboxam, FRAC 22) which is labelled for oomycete diseases on cucurbits, ginseng, pepper/eggplant and tuberous and corm vegetables.

Managing downy mildew organically is much more challenging. Copper-based products are the primary tool but can also cause phytotoxicity. Other organic options include the microbial biopesticides Actinovate, Double Nickel 55, Serenade and Sonata as well as the biochemical biopesticides MilStop, Organocide, Oxidate, Regalia, Sporatec and Trilogy. Zonix is an OMRI-approved rhamnolipid surfactant which has shown some efficacy when included in a regular spray program.

Since downy mildew disease forecasting is an important tool utilized by growers, extension educators, crop consultants and other industry stakeholders, confirming reports especially early in the season and on different cucurbit crops is important at both a local and regional level. If you suspect downy mildew on your farm please let me know either by email at bkgugino@psu.edu or by phone at 814-865-7328 or contact your local Cooperative Extension Office.

HOW TO CONTROL GLYPHOSATE RESISTANT WEEDS IN VEGETABLES?

Dwight Lingenfelter
Penn State University, Dept. of Plant Science, 116 ASI Building, University Park, PA 16802

Herbicide resistance in weeds in not a new phenomenon. The use of synthetic herbicides dates back only to the 1950s. However, since then there are weed populations that have developed resistance to certain herbicide modes of action. During the 1980s, many lambsquarters and smooth pigweed populations across the region became resistant to triazine herbicides (Group 5); in the 90s, the ALS-inhibitor herbicides (Group 2) were less effective on weeds such as giant foxtail and redroot pigweed; and as we moved into the 2000s, more weed species are becoming resistant to glyphosate (Group 9). Currently, the most pervasive weed biotype that is resistant to glyphosate is marestail (aka, horseweed). Also, within the past several years, glyphosate-resistant Palmer amaranth and waterhemp have moved into the region causing more challenges to our production systems.

Glyphosate-resistant marestail *(Conyza canadensis*) is a problem in most crops throughout the state including, agronomic and horticultural row crops, orchards, vineyards, and many other areas such as roadsides, non-crop areas, and other natural or idle areas.

Marestail has received increased attention due to the identification of glyphosate and ALS resistant populations around the country. Marestail is a member of the aster or sunflower family. It starts out as a small rosette and as it grows upright its hairy leaves whorl around a central stem. Mature plants become 2 to 5 feet tall producing numerous small daisy-like flowers. Marestail is a prolific seed producer (>100,000 seeds/plant) and the seeds are wind dispersed much like dandelion. Marestail has traditionally been considered to have a winter annual life cycle. It typically germinates in the fall and overwinters as a rosette then bolts and sets seed by summer. However, there is another biotype of marestail that can also be found in our region. This one doesn't germinate until early spring and completes its lifecycle by late summer. The two different lifecycles can cause problems when managing marestail especially when trying to grow crops planted either earlier or later in the growing season. This too can poses problems when selecting burndown and residual herbicide programs depending on the cropping system. A few things to consider when managing marestail: first, its seeds are very small and it does not tolerate tillage. If the seed can be buried at least a quarter of an inch, germination is drastically decreased. Also, once marestail gets to be taller than 6 inches, it is difficult to control with herbicides. Herbicide applications in the fall or early spring when it is in the rosette stage are best.

The number of herbicides that are effective on marestail is rather limited in vegetable and orchard systems. A few include:

Soil-applied (PRE)	**Foliar-applied (POST)**
Alion	2,4-D
Atrazine	dicamba
Chateau	Gramoxone
Metribuzin	Liberty/Rely
Simazine	Sharpen/Treevix
Spartan/Authority	Stinger

Dwight Lingenfelter is an extension agronomist/weed scientist in the Dept. of Plant Science at Penn State since 1994. He is responsible for developing various materials for Extension purposes, including revising portions of The Penn State Agronomy Guide, presenting practical information at county and statewide Extension meetings and field days, and generally contributing to other weed science Extension and research needs in mainly agronomic and some vegetable crops. He also coordinates the annual Penn State Agronomic Field Diagnostic Clinic and coaches the PSU collegiate weed science team and is a member of several professional societies and serves on various committees. He received BS and MS degrees in Agronomy from Penn State. He also worked for a period with a major ag chemical manufacturer and as a crop consultant. (2013)

Two, new noxious pigweed species namely, Palmer amaranth and waterhemp are invading croplands in Pennsylvania. Palmer amaranth (*Amaranthus palmeri*), also known as Palmer pigweed, was recently introduced into Pennsylvania agricultural systems. Infestations were primarily observed in soybean, corn, alfalfa, and around barnyards but it is likely in some vegetable and tree crops as well. It poses unique management challenges that most farmers in this region have not had to contend with before. Containing new infestations and preventing its spread is a critical first step to managing this new threat. The risk from this new weed comes from its competitive and aggressive growth habit, prolific seed production (greater than 300,000 seeds per plant), prolonged germination pattern, along with its potential resistance to glyphosate (Group 9) and the Group 2 herbicides (ALS-inhibitors). Resistance to other herbicide classes has also been documented in this species (Groups 3 and 5). Palmer amaranth is a summer annual broadleaf weed that is native to the southwestern US and Mexico. Palmer amaranth is related to other pigweeds in the Northeast region including redroot, smooth, Powell, and spiny, but unlike these other pigweeds, Palmer amaranth grows faster and is dioecious. Pollen from male plants can travel with the wind to susceptible female plants and if the male is herbicide resistant, a portion of the offspring will also be resistant. Palmer amaranth is extremely aggressive and some common identifying features include:

- smooth stems
- rosette pattern; leaf architecture around stem resembles a poinsettia
- singular hair in tip of leaf notch when it is small (<6" tall)
- long petiole (stalk that attaches leaf to stem); with Palmer, the petioles will be as long as or longer than the leaf blade
- "watermark" or chevron pattern on some leaves (not necessarily on every plant)
- male and female plants and long seed heads; Palmer amaranth is dioecious meaning that male and female flowers are on separate plants (compared to monecious like redroot or smooth where they are both on the same plant). Male and female flowers are quite different from one another and distinctive. The mature inflorescence spikes are 6 to 36 inches long for both male and females with the main terminal seed head being the longest. The female has flower bracts that are prickly and painful to the touch; males are not painful and have anthers and pollen rather than these painful bracts. These female bracts are not spines or modified leaves like spiny amaranth, but rather part of the female flower.
- Thick "root crown"; lower stalks of Palmer can be 2 to 5 inches in diameter

Waterhemp (*Amaranthus tuberculatus*), another dioecious herbicide resistant pigweed species common in the Midwest is also getting a foothold in the area. Currently, there are at least three documented infestations and a few other sites have been reported. Although not as great a competitive threat as Palmer amaranth, it too should be aggressively managed to prevent its spread since it will certainly compete in Pennsylvania cropping systems. It is uncertain how Palmer amaranth and waterhemp populations were introduced to the farms, but equipment, hay, feed, manure, and compost are all suspected. Contaminated cotton seed from the south or west, used in dairy rations, may also be involved. Herbicide options for Palmer pigweed and waterhemp control can be limited in soybean, alfalfa, and vegetable productions systems; however more options exist in corn and pasture. Timely applications and a combination of preemergence/residual and postemergence herbicides containing at least two effective modes of action are critical for practical management of these species. Like marestail, the number of herbicides that are effective on Palmer and waterhemp are rather limited in vegetable and orchard systems; several include:

Soil-applied (PRE)	Foliar-applied (POST)
Atrazine/simazine	Aim/Cadet
Boundary	Callisto/Impact/Armezon/Laudis
Chateau	Dicamba
Dual Magnum	Raptor
Harness/acetochlor	Reflex
Metribuzin	
Spartan/Authority	
Zidua/Anthem	

Other management considerations include the use of incoming herbicide resistant crop varieties (i.e, 2,4-D-, dicamba-, and HPPD-resistant field crop traits), more diverse crop rotations, cover crops, and mechanical tactics, among others. Education of farmers and agricultural service providers about these unwelcomed weed species, their negative impacts, and management are of vital importance.

Palmer amaranth and waterhemp are like no other weed we have encountered in our region. They must be taken seriously otherwise they will continue to spread and cause major problems for agronomic and horticultural crop production.

Strategies for Managing Herbicide Resistant Weeds

Dependence on a single strategy or herbicide family for managing weeds will increase the likelihood of additional herbicide resistance problems in the future. **Management programs to combat herbicide resistance should emphasize an integrated approach.** Some management guidelines for an integrated approach include judicious use of herbicides, using herbicide tank mixtures containing more than one herbicide mode of action that are active on similar weeds, shorter residual herbicides, crop rotations that allow for application of different herbicide classes, nonchemical control measures, and combinations of weed management techniques such as avoiding spreading resistant weed seed with machinery or in manure and ensiling to help destroy weed-seed-infested forage.

Reducing the risk for developing herbicide-resistant weed populations requires incorporating a number of guidelines in managing your fields, including:

- Spray only when necessary
- Use alternative methods of control whenever possible such as tillage and mechanical cultivation or delayed planting (row crops), mowing (forage crops), and using weed-free crop seeds
- Rotate crops and their accompanying herbicides' site of action
- Limit number of applications of herbicide(s) with same site of action in a given growing season
- Use mixtures or sequential herbicide treatments having different sites of action that will control the weeds of concern
- Scout fields after herbicide application to detect weed escapes or shifts
- Clean equipment before leaving fields infested with or suspected to have resistant weeds

Pennsylvania Noxious Weed Law

The Pennsylvania Controlled Plant and Noxious Weed Act (or commonly referred to as the Noxious Weed Law) was signed into law in October 2017. The new Act replaces the Noxious Weed Control Law that has been in place since 1982. The new Act will modernize Pennsylvania noxious weed law by prioritizing invasive plant management based on the ability to effectively contain or even eradicate certain species. In addition, it will help build awareness of problem weed species that require proactive attention. It groups weeds into three different categories (Class A, B, & C).

Class A weeds are currently geographically limited in the Commonwealth and are intended to be eradicated if at all possible. The list includes:

- Palmer amaranth (*Amaranthus palmeri*)
- Waterhemp (*Amaranthus rudis* and *tuberculatus*)
- Animated oat (*Avena sterilis*)
- Dodder (*Cuscuta* spp.)
- Goatsrue (*Galega officinalis*)
- Giant hogweed (*Heracleum mantegazzianum*)
- Hydrilla (*Hydrilla verticillata*)
- Wavyleaf basketgrass (*Oplismenus hirtellus*)
- Broomrape (*Orobanche* spp.)
- Kudzu (*Pueraria lobate*)

Class B weeds are widely established in the Commonwealth and it is not feasible to eradicate them. Although they are still important, limited resources must be focused on the species that will maximize impact. The list includes:

- Musk thistle (*Carduus nutans*)
- Canada thistle (*Cirsium arvense*)
- Bull thistle (*Cirsium vulgare*)
- Purple loosestrife (Exotic *Lythrum* spp.)
- Mile-a-minute (*Persicaria perfoliata*)
- Multiflora rose (*Rosa multiflora*)
- Shattercane (*Sorghum bicolor*)
- Johnsongrass (*Sorghum halepense*)

Class C weeds pose a potential threat if introduced, but currently are not known to exist in the Commonwealth. A number of Federal noxious weeds are Class C weeds.

Now that the law is in effect the Department of Agriculture may issue a control order requiring a person or landowner to implement treatment measures to manage the weed. However, who does this monitoring and how actively will it be patrolled has yet to be determined. But keep in mind, if you have these weeds on your farm it is best to get them under control.

What does the new noxious weed law mean to Pennsylvania?

First and foremost, it can provide increased awareness to recognize that certain weed species are a big problem. Class A weeds such as Palmer amaranth and waterhemp will require proactive management and this will help direct educational efforts. Proactive management reduces the chance of movement and introduction onto your farm or in your area. Of course, there are costs associated with monitoring and managing noxious weeds. With the invasive pigweeds, Pennsylvania imports unwanted seed through other commodities and equipment. This will require additional quality control measures for feed, seed, and forage producers. The seed industry will need to evaluate seed sources, making sure they have a quality product that does not contain noxious weed seed. Custom equipment operators will need to be diligent about where they operate and about cleaning equipment if they encounter a contaminated farm. Farm supply and export enterprises need to be part of the solution to ensure that noxious weeds are not transported or spread within or out of the state. In the end, the new Controlled Plant and Noxious Weed Act can help to protect the productivity and profitability of the Commonwealth and position Pennsylvania as a leader among other states regarding proactive weed management.

CHALLENGES AND OPPORTUNITIES FOR SOIL HEALTH IN ORGANIC VEGETABLES

Franklin Egan, Pennsylvania Association for Sustainable Agriculture
franklin@pasafarming.org

Soil health is the foundation of productivity and profitability on any farm. While most farms regularly test their soils, it can be challenging to put results in a meaningful context. For instance, how do you understand what a "good" soil test result is for your farm, and how do you develop a practical strategy for improving soil health over the long term?

Over the summer of 2016, the Pennsylvania Association for Sustainable Agriculture (PASA) began working with organic vegetable farmers to help answer these questions and chart a course for sustaining our soil resources for the future. PASA worked with twelve organic vegetable farmers across Pennsylvania to measure soil health in their fields and assess management practices that influence soil health. We submitted soil samples to the Cornell Comprehensive Assessment of Soil Health and gathered management records for tillage operations, planting dates, and soil amendments.

The data help to illustrate what is typical, and what is possible, for soil health on diversified organic vegetable farms in Pennsylvania (Table 1). We found that, on average, PASA vegetable farmers:

- Grow organic matter levels 1.3 times higher than Natural Resource Conservation Service expectations for their soil types.
- Maintain living vegetative cover on their soils 225 days of the year, 70 days longer than typical Pennsylvania row crop practices.
- Show Cornell Soil Health scores of 70, an "excellent" rating in the Cornell Comprehensive Assessment, which combines 12 different metrics into a 0-100 scale.

These are very beneficial outcomes for our farms, neighbors, and the planet. Drawing on this data, PASA is working to tell the story of soil stewardship and help to expand the market and public support for organic vegetables. For instance, we're developing an infographic that summarizes our research findings and concisely explains to a non-farmer why soil health is so important for ensuring healthy food and a healthy environment (see Figure 1). PASA farmers can place these fact sheets on their farm market stands, add them to CSA boxes, or share them with a wholesale customer.

Our study will also provide a framework for organic farmers to share best practices and collaboratively develop new ideas for growing soil health. For instance, at our Soil Health Conferenec this past summer farmers Will, Mike, and Terrra Brownback from Spiral Path Farm shared results from their PASA soil health assessment, in which they showed leading scores among study participants. Spiral Path is a 225-acre organic vegetable operation near Loysville, PA, and through forty years of farming organically, the Brownbacks have boosted their soil organic matter to impressive levels. In one field, we measured 5.1% soil organic matter, on a soil type that typically holds only about 2.0%.

At the soil health fielday, the Brownbacks stressed that building healthy soils requires a long-term commitment, with regular assessment as part of the process. They also described Spiral Path's composting system, which they do not view primarily as a direct source of nutrients, but rather as a way to prime the soil microbiology and help plants access nutrients stored in soil organic matter. The Brownbacks also explained that although Spiral Path does rely

Franklin joined PASA in June 2015 as our first Director of Educational Programs. Franklin will be leading PASA's efforts to develop a rigorous new farmer training program, enhance networks for farmer to farmer learning, and build a platform for on-farm research and experimentation. Franklin holds a PhD in Ecology from Penn State University, and he has conducted research on topics including biodiversity conservation on farmland, environmental risks from genetically-modified crops, and improving the efficiency of pasture-based dairies.
Franklin lives in Boalsburg, PA, with his wife Glenna and daughter Rosalyn. Outside of work, he enjoys gardening, music, reading, and generally spending time outdoors in beautiful Central Pennsylvania.

on pretty intensive tillage for weed control and terminating cover crops (often including multiple passes with a disc plow), they are very disciplined about tilling when soil moisture conditions are appropriate. By avoiding compacting wet soils with heavy equipment, they are able to use tillage while steadily increasing organic matter with healthy crops and cover crops. Thus far, our study corroborates the Brownbacks' philosophy on tillage, and the data suggest that in well-managed organic vegetable rotations, tillage can be compatible with soil health (Figure 2).

We've expanded on our study for 2017, and have built a research network including 25 organic vegetable farms, while also working to include four row crop farms from the PA NoTill Alliance. This home-grown dataset will serve to guide soil health education and outreach at PASA and provide a foundation for farmer-to-farmer learning about best practices for growing soil health. Please contact Franklin Egan with any questions about this exciting project: 814-349-9856 or franklin@pasafarming.org.

Table 1: Highlights from PASA's 2016 soil health benchmark study

SOIL HEALTH INDICATOR	PASA MEAN	MIN-MAX
Organic Matter, as measured in 2016	3.30%	1.6-5.1
Organic Matter, relative to rating for soil type[1]	1.3x	0.7-2.6
Days in Living Cover[2]	224 days	138-320
Cornell Soil Health Score[3]	70	54-84
Tillage Intensity Index[4]	5	1.2-9

[1] This value reflects the ratio of organic matter measured in 2016 to NRCS organic matter ratings for each farm's soil type. Sampled farms had organic matter 2.3 times higher, on average, than NRCS ratings.

[2] This indicator reflects area-weighted vegetative cover estimates for all crops and cover crops for the 2016 season. For context, a typically Pennsyvlvania soy-corn rotation without cover crops would achieve 156 days of cover, according to National Agricultural Statistics Service data.

[3] The Cornell Soil Health Score incorporates twelve different measurements of soil physical, biological, and chemical properties into a 100-point scale. Scores of 60-80 are considered "excellent"; scores higher than 80 are considered "optimal".

[4] The tillage intensity index uses NRCS data to assign a soil disturbance score to each tillage or cultivation implement used in 2016. For example, a single moldboard plow pass gets a score of 1.0; a tine-weeder pass gets a 0.5. Higher scores indicate more frequent, extensive and/or deeper soil disturbance.

Figure 1. Sample PASA Soil Health Marketing Infographic

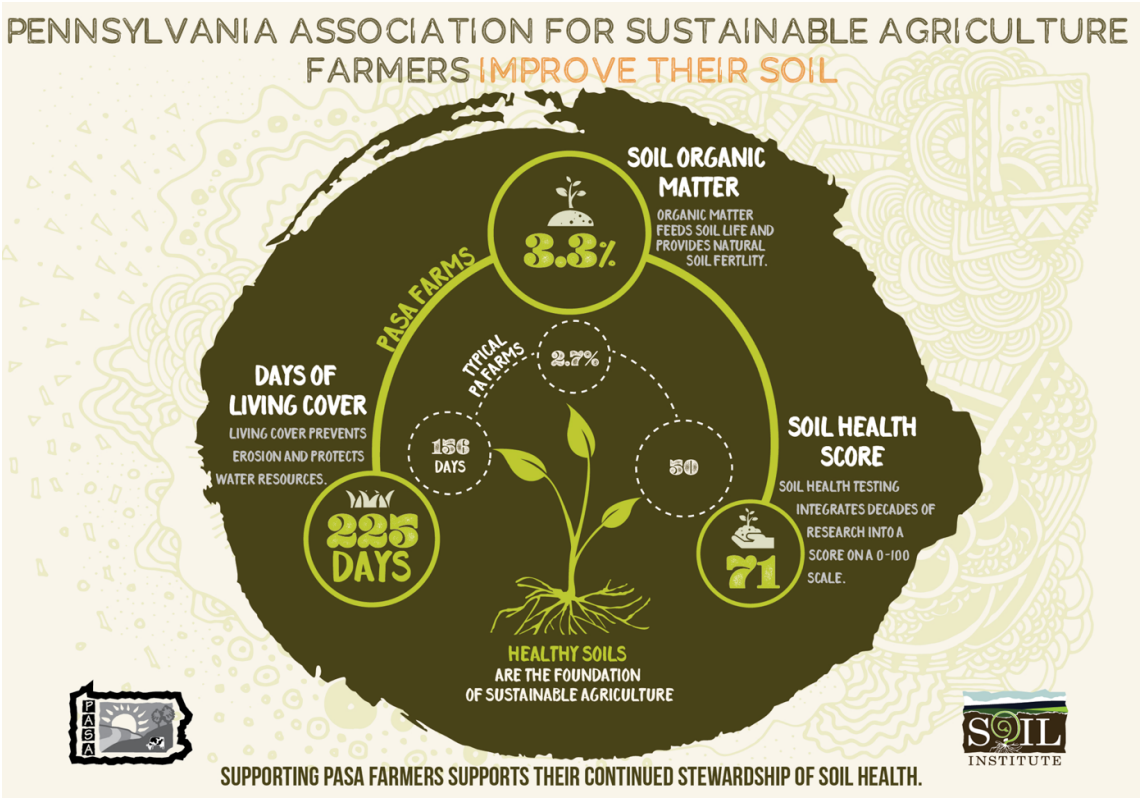
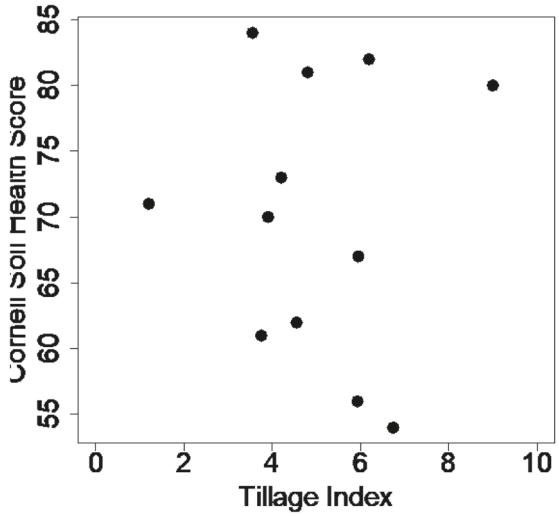


Figure 2. Relationship between annual tillage intensity and soil health, as measured through the Cornell Comprehensive Assessment of Soil Health, on 12 Pennsylvania Organic Vegetable Farms.



NO-TILL VS PLASTIC BED VEGETABLES

Elsa Sánchez, Pennsylvania State University

Currently, plastic bed production systems, using raised beds, drip irrigation, and typically black plastic mulch, are commonly used to grow vegetables. Crop yields are often earlier and higher and weeds within the planting row are suppressed using plastic bed production systems compared to bare ground and reduced tillage growing systems. This production system also has drawbacks, however. Among them are that extensive tillage is needed to prepare the field for planting which can reduce soil quality and increase soil erosion. Environmental and economic concerns also surround the use and disposal of plastic mulch. Additionally, plastic bed production systems are not suited for all areas. For example, they are difficult to use on hilly ground. Reduced tillage systems may be an alternative to plastic bed systems to minimize these concerns.

Recently, in 2013-14, we completed an experiment comparing a strip tillage system to a plastic bed production system for muskmelon and summer squash at Penn State's research farm in Rock Springs. Studies have compared strip tillage to bare ground production, but at the time, we were not aware of other experiments comparing strip tillage to plastic bed systems. The study also used row covers to manage cucumber beetles which can transmit cucumber wit, a fatal disease that can affect almost all cucurbit crops in our area.

The research was designed as four separate experiments focusing on a different crop and either organic or conventional management:

1. Organic muskmelon
2. Organic summer squash
3. Conventional muskmelon
4. Conventional summer squash

The muskmelon cultivar used was Athena and the summer squash cultivar was Lioness. Additionally, each experiment was conducted over a 2-year period.

For all experiments, a cover crop seeding mix of 75% winter rye and 25% hairy vetch at a rate of 90 lb/A was planted in the fall before each growing season. In the two organic experiments, a roller crimper was used to terminate the cover crop and applications of glyphosate were used in the two conventional experiments.

In all experiments, strip tillage consisted of tilling a 12-inch-wide row through the rye/hairy vetch residue with a single line of drip tape per row. Plastic bed systems consisted of 2.5 ft wide raised beds with a single row of drip tape and black plastic mulch over the beds.

In all experiments, row covers (Agribond AG-30 for the two summer squash experiments and conventional muskmelon experiment, AG-19 for the organic muskmelon experiment) were deployed at transplanting over half of the plants, while the other half were left uncovered. Row covers were removed when 50% of the strip tillage plots had at least one open flower for the two summer squash experiments and 10 days after first flowering for the two muskmelon experiments.

Elsa Sánchez is an Associate Professor of Horticulture in the Department of Plant Science at Penn State University. Her responsibilities are 60% extension and 40% undergraduate teaching. Current extension projects focus on sustainable and organic production of vegetable crops. She earned a BS in Horticulture and a MS in Agricultural Biology at New Mexico State University and a PhD in Horticulture at Washington State University. Elsa and her husband, Chris, live in State College, PA with their daughters Laurel and Lilly

Air and soil temperatures were measured in the organic muskmelon and summer squash experiments only. In both experiments, average air temperatures were not different between plastic bed and strip tillage treatments during the period of row cover deployment. However, air temperatures were about 5.3°F higher when using row covers compared to not using them. Average soil temperatures were about 3.5°F higher in plastic bed treatments compared to strip tillage treatments during the period of row cover deployment. The use of row cover did not impact soil temperatures.

The incidence of bacterial wilt was low in all experiments and both study years. Additionally, cucumber beetles were sprayed with insecticides when numbers exceeded thresholds. We were unable to test the effects of the treatments on these factors.

Overall, for all four experiments, using a plastic bed system generally resulted in higher yields than the strip tillage system, possibly related to soil temperature as well as other factors, including soil nitrate levels and weed pressure. While some yield loss may be acceptable in strip tillage systems due to decreased field preparation time and decreased input costs, the reduction in yield seen in the two muskmelon experiments was beyond an acceptable level. In the organic summer squash experiment yield was also unacceptably lower than observed in the plastic bed system. In 2014, yield from conventional summer squash grown in the strip tillage system was not different than from the plastic bed system; however, significantly lower yields were observed in 2013.

Plastic bed systems resulted in overall higher yields, warmer soil temperatures, and fewer weeds compared to strip tillage systems. We looked back at the experiment for ways we might be able to alter the strip tillage system so that yields were more comparable to plastic beds. One idea was to adjust plant populations. Plant populations are typically dependent on bed shaping and plastic laying equipment; beds are usually about 6 to 8 feet apart center-to-center. Beds can be spaced much closer in strip tillage and reduced tillage systems. For example, they can be as close as 4 feet center-to-center in bare ground production systems. By altering plant populations, it may be possible to increase yield per area, for example, per acre, even if yield per plant is lower than in plastic bed systems.

Fewer weeds have been seen in no-till systems compared to conventionally tilled systems. Dr. Sjoerd Duiker, a professor at Penn State, has studied no-till systems using various cover crops for agronomic crops for years. He has studied how the amount of cover crop residue affects weed populations and we can adapt this information to no-till vegetable crops.

In 2017, we conducted a preliminary study comparing no-till and plastic bed production of tomato and butternut squash. We planted into a rye cover crop. Rows were spaced 4 feet center-to-center in the no-till system and 7 feet center-to-center in the plastic bed system. In-row spacing was 18 inches in both production systems. When examining yield per plant, using plastic beds resulted in higher tomato and winter squash yields. Then we looked at yield per acre. Tomato yields were not different in both production systems and butternut squash yields were higher from the no-till system. One issue that has been mentioned by growers, and that we experienced, was delayed yield from the no-till system. We were able to harvest from plants grown on plastic beds about a week earlier for both crops.

Warmer soil temperatures obtained in plastic bed systems is a factor in higher yield, but also in faster maturity of vegetables. As we saw, yields can be earlier in plastic bed systems compared to reduced tillage systems. We would like to continue investigating no-till systems compared to plastic bed systems and have some ideas for tackling the earliness issue. We are interested in your experiences with no-till vegetables and any ideas you have for approaching the earliness problem. We can be reached by email at esanchez@psu.edu (Elsa Sánchez) or sduiker@psu.edu (Sjoerd Duiker).

SOIL HEALTH AND PEST MANAGEMENT

Dr. Mary Barbercheck
Penn State University, 501 ASI Bldg., University Park, PA 16802. meb34@psu.edu

What is soil?
Soil is a complex ecosystem composed of organisms living within a complex matrix of mineral and organic particles, gases, water, nutrients, and other chemical elements. In addition to providing mechanical support for growing plants, a healthy soil absorbs, holds, and releases water; exchanges gases; cycles nutrients and converts nutrients tied up in organic matter into plant-available nutrients; assimilates carbon into humus; resists erosion; suppresses insect pests and plant pathogens, and sustains biodiversity.

Soil Quality and Soil Health
In an agricultural system, soil health or soil quality refers to the ability of the soil to sustain productivity and protect environmental resources. Soil health is an assessment of the state of soil functioning in relation to the desired use of the soil and primarily considers properties of soil that can be changed through management. A healthy soil provides many functions that support plant growth, including nutrient cycling, biological control of plant pests, and regulation of water and air supply. Physical, chemical, and biological properties of soil all interact to influence soil functioning. Soil organic matter plays an especially important role in soil health, as it regulates many key physical, chemical, and biological properties of soil.

The Soil Food Web
Soil is home to a complex community of organisms that interact to impact above-ground and below-ground processes. The soil food web is comprised of the community of organisms living all or part of their lives in the soil. Soil-dwelling organisms play key roles in soil function, providing the foundation for critical processes such as soil structure development, decomposition and nutrient cycling, promotion of plant health and diversity, and regulation of pest organisms. Soil life ranges in size from microscopic to easily observable with the unaided eye, and includes:

- Microbes, including bacteria, fungi, and protozoa: the primary decomposers of soil organic matter. They contribute to nutrient cycling and breakdown of organic material to release plant-available nutrients from organic residues. Microbes in the soil can interact with plant roots to induce plant host defenses through biochemical changes that enhance resistance of the plant against infection by pathogens or to attack from plant-feeding insects. This phenomenon is called *induced systemic resistance*.
- Larger organisms: For example, free-living nematodes and small arthropods help to mediate the breakdown of plant and other organic residues, and the mineralization of plant nutrients from those residues by breaking apart relatively large fragments of organic residues to smaller pieces with increased moisture and surface area for the primary microbial decomposers to act on. A component of a healthy, biologically active soil that is of particular interest in agricultural systems for the control of arthropod pests include a wide range of predators, parasites and pathogens that contribute to the suppression of agricultural pests.

What do beneficial soil organisms need?
Soil organisms need the same resources as all other living beings: *space, air, water, and food.* The way that we manage soil impacts the resources available to soil organisms and to their functioning.

- *Space:* Soil particles are grouped together in the soil formation processes to create structural pieces called aggregates. Clay, organic matter, root hairs, organic compounds from bacteria and fungi, and fungal hyphae

Mary Barbercheck is a Professor of Entomology at Penn State. She conducts research and extension in sustainable and organic agriculture. Her research focus is on the biological aspects of soil health and it's role in pest suppression, and the effects of management practices on beneficial soil organisms. Originally from northwest Indiana, she has a B.A. in Environmental Biology from the University of California at Santa Barbara, and a Master's degree in Plant Protection and Pest Management and a Ph.D. in Entomology from the University of California at Davis. Before joining the faculty at Penn State in 2002, she held a faculty position as soil entomologist in the Dept. of Entomology at North Carolina State University from 1990 – 2002. Mary and her husband Dan enjoy living in the country with three donkeys, a horse, two dogs and two cats.

help "glue" soil aggregates together. The significance of soil aggregation is that it creates soil pores or voids that are the living spaces for most soil organisms, and they hold air and water. Therefore, a healthy soil is similar to a sponge – consisting of a network of pores, channels, and solid material. Many beneficial soil organisms are too small to move soil, and live in the existing pores and channels in well-aggregated soil. Some soil organisms are capable of moving soil and creating macropores and channels in the soil. These organisms, sometimes called *ecosystem engineers*, include termites, ants, dung beetles, and earthworms.

- *Air and water:* Water and air are held in the pore space between soil particles and soil aggregates. Larger pores, known as macropores, are important to promote good aeration and rapid infiltration of rainfall. Smaller pores, known as micropores, are important for absorbing and holding water. To maintain both adequate aeration and water supply for optimum plant growth, it is necessary to have both macro- and micropores in the soil.
- *Food*: Organic matter in soil plays an important role in integrating many aspects of soil health. Soil organic matter is the base fuel that supports a healthy food web and provides nutrients used by plants and other organisms. Soil organic matter includes all the organic substances in or on the soil, including plant- and animal-derived material, in various stages of decay. The quantity of organic matter in a given soil is also the result of a balance between organic matter inputs, such as crop residues, manure, and compost, and the rate of organic matter decomposition. Both organic matter inputs and the rate of decomposition can be influenced by soil management practices. Reduction of tillage frequency or intensity, growth of overwintering cover crops, crops with fibrous roots such as small grains, and returning crop residues to soil can help increase labile organic matter in soil.

How is healthy soil related to insect pest management?

Insect populations are affected by interactions in food webs. If we consider a simple food chain that includes a plant-feeding insect, there are organisms lower than the plant-feeding insect on the food chain (e.g., plants) and organisms higher than the plant-feeding insect (e.g., predators, parasites, and pathogens). Factors that affect insect populations from lower in the food chain are called "bottom-up factors," and factors from higher in the food chain are called "top-down factors." Soil management interacts with bottom-up and top-down factors to regulate populations of plant-feeding insects.

- *Bottom-up effects:* In natural systems, germinating seeds recruit particular microbes and establish beneficial associations that can last throughout the plant's entire life cycle. Plants in intensive cultivation may lose defensive and growth-promoting root associates and endophytes (beneficial microorganisms that can grow in plants). Restoration and conservation of root associates and endophytes in agricultural crops could result in reduction of fertility and pest management inputs, and crops better able to tolerate and recover from environmental and biological stresses. There are many root-associated microorganisms that can affect the suitability of the plant as a host for plant-feeding insects, e.g., mycorrhizal fungi and multifunctional insect pathogens that can also grow in association with plant roots as well as infect and kill insects directly.
- *Top-down effects*: There are many organisms, broadly called natural enemies, that prey upon or parasitize plant-feeding insects. Some of these can be purchased, and released to help manage pests. However, a more efficient approach can be to conserve and promote natural enemies. Intensive tillage and lack of surface residues can be detrimental to soil health and can reduce populations of natural enemies. Surface residues or areas of reduced disturbance can provide habitat to conserve beneficial predators such as ground beetles and spiders. Broad-spectrum, systemic insecticides, such as neonicotinoids, can kill beneficial ground beetles, and can result in increases in some pests, such as slugs.

Soil management to promote pest management

Avoid compaction. The wetter the soil, the easier it is to compact the soil. As the structural units are broken down when a soil is compacted, the pore space is reduced. Reduced pore space reduces aeration in the soils necessary for root growth and biological activity. Don't walk or drive on wet soils and never till wet soils.

Plant cover crops. Green manures, or cover crops, such as annual rye, ryegrass are planted in the fall for incorporation in spring. Cover cropping provides additional organic matter, holds nutrients that might have been lost over the winter, and helps reduce erosion and loss of topsoil. Legume cover crops, such as red clover, crimson clover, or hairy vetch can increase the amount of nitrogen in the soil and reduce fertilizer needs.

Increase organic matter inputs. Regularly adding manures, compost, cover crops, and other organic materials can raise the soil's nutrient level and physical quality, thus reducing the need for synthetic fertilizers.

Reduce frequency and intensity of tillage. Tillage increases oxygen in the soil, stimulating microbial activity, and results in the decomposition of organic matter. If additions of organic matter are not sufficient to counteract the losses from decomposition, organic matter levels will decline over time, reducing soil health. Diversity and abundance of arthropod predators associated with the soil surface can be greater under reduced-tillage management in comparison to conventional tillage, and natural control of pest insects in soil may be enhanced in reduced tillage systems. When tillage is used it is important to offset the increased rate of organic matter decomposition with increased inputs of organic matter through crop residues, manure, and compost.

Reduce pesticide use and provide habitat for beneficial organisms. The application of broad-spectrum insecticides can kill beneficial insects, like ground beetles, directly, or indirectly, by interfering with the reproductive development or behavior of the organism. Practices to increase and manage biodiversity with the goal of increasing the presence of beneficial organisms include the use of insectary plants, hedgerows, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, spiders, amphibians, reptiles, bats, and birds that parasitize or prey upon insect pests. Natural areas placed in contours between fields, steep ditches, or places that are easily eroded gives stability to the soil. Natural areas can also be used as a filter strip to prevent water runoff and soil erosion.

Rotate crops. Diverse crop rotations help to break up soil-borne pest and disease life cycles, improving plant health. Rotations can also assist in managing weeds. By growing diverse crops in time and space, pests that thrive within a certain crop are not given a chance to build their population over time. Rotating crops can also help to reduce nutrient excesses.

Manage soil fertility carefully. Planning the timing, application method, and quantity of manure, compost, and other fertilizers will allow you to meet crop nutrient demands and minimize nutrient excesses. Healthy, vigorous plants that grow quickly are better able to withstand pest damage. However, over-fertilizing crops can increase pest problems. Increasing soluble nitrogen levels in plants can decrease their resistance to pests, resulting in higher pest density and crop damage. There is some evidence that synthetic nitrogen fertilizers reduce soil organic matter. Manure and compost add organic matter as well as an array of nutrients, but using just compost or manure to meet the nitrogen needs of the crop every year can result in excessive phosphorus levels in the soil.

TRIALS, TRIBULATIONS AND TRIUMPHS IN WEED CONTROL IN NO-TILL ORGANIC VEGETABLES SYSTEMS

Jerry Brust, IPM Vegetable Specialist, University of Maryland

Soil organic matter or soil carbon is essential in developing a healthy soil system. Soil organic matter can help improve soil physical properties such as infiltration rate, water-holding capacity, aggregate stability, soil structure, soil aeration, and a host of other physical properties. In addition, soil organic matter can contribute significantly to improving soil nutrient pools and other chemical properties. Keeping plant residues intact is a critical component of soil management, not only for nutrient value, but also for soil protection from wind and water erosion. The breakdown of residue through conventional tillage and soil disturbance must be minimized in order to retain organic matter or carbon in the soil system. The exposure of soil organic matter to aeration during tillage increases CO_2 emissions, which removes organic matter from the soil and leads to a decline in soil fertility and aggregate stability.

Reducing the amount of soil disturbance will decrease the loss of soil organic matter in any soil system, but how can no-tillage be accomplished in an organic vegetable system? Organic vegetable growers have a hard time managing weeds, as there are no *reliable* Organic Materials Review Institute (OMRI) chemicals for controlling grass or broad leaf weeds. Most of the time growers depend on tillage for weed control, but excess tillage can lead to destruction of soil structure and the loss of carbon from the soil. No-tilling cover crops is a possibility, but has several problems, most notably being unreliable as a season-long weed control method. Recent research I have conducted looks at using no-tillage and the addition of a weed barrier for season-long weed control in organic vegetable systems.

Cover crops of rye, hairy vetch, hairy vetch+rye, tillage radish and no cover crop have been grown over the last five years and vegetables have been planted into these various cover crops which were managed in several different ways for weed control. The basis for all the methods is creating a stale seed-bed. Loosely defined a stale seed-bed is when the soil is disturbed once and a flush of weed growth occurs, this weed growth is then controlled either with chemicals or in organic systems with various weed barriers. This report examines using no-till cover crops for weed control in organic vegetables.

The roller-crimper is an implement (Fig. 1) used to break (crimp) stems of cover crops in several places along the length of the plants to more completely dry out the plants than if they were simply rolled. This crimping must be done at certain phenological times in the growth of the cover crop or the stems will be too resilient and will not crimp sufficiently to die (Fig. 2). For hairy vetch, plants must be in late flowering with seed pods just beginning to form on the stem. For rye the seed-heads should be in early dough stage for crimping to take place. Tillage radish cannot be crimped and should winter kill (but sometimes it does not). Waiting for the best time to crimp can lead to later plantings usually in late May or in early June in central Maryland.

The first couple of years I no-tilled sweet corn into the crimped cover crops of vetch and rye. In dry years this worked pretty well with good ground cover (Fig. 3). However in other years the grass was so bad that yields of sweet corn were reduced by 40%. The worst years are the ones that have a great deal of rain, especially large thunderstorms that drop several inches of rain in a short period and then it dries out for many days. The grasses respond to this by growing rapidly through the mulch and taking up much of the rain water and nutrients during the rest of the summer.

In the last few years I have used weed barriers on top of the tilled soil, but especially on top of the crimped cover crops. These barriers are cloth-like but tough (still using the same ones after 6 years) that allow rain to pass through. These barriers are then placed alongside plants in a row and staked down for 1-2 weeks. I usually try to cover weeds

Gerald Brust is the IPM Vegetable Specialist at the University of Maryland located at the Central Maryland Research and Education Center near Upper Marlboro, MD. He is responsible for developing new IPM programs for insect pests and new nutrient management programs for vegetables for Maryland and mid-Atlantic growers. Before coming to Maryland he worked for four years for a private consulting company in south Florida developing bioIPM programs for the company's vegetable grower clientele. Prior to Florida he worked for Purdue University developing IPM programs for Midwestern vegetable growers. His wife, Karen Rane is the Director of the University of Maryland's Diagnostic Laboratory and their two children are in grad school. He has an MS degree from The Ohio State University and his PhD from North Carolina State University

after they have flushed and are small, but sometimes the weeds get ahead of me. As an example, in a no-till crimped area of a tomato field in early June after several heavy rains, a good stand of grass became established. I did not think there was much hope for the barriers to work, but I laid down a 50 ft long x 4 ft wide weed-barrier on either side of the tomato rows and let them sit for just 2 weeks and then I moved them by taking out the ground pins and sliding the barriers down the row until they reached the prior end of the barrier. The grass weeds were not only dead, but also added to the mulch layer of rye and vetch (Fig. 4). The barrier was moved, slid-down another 50 ft for 2 weeks to kill the grass in that area of the tomato field. The barrier works best when it is sunny, hot and dry. That makes the results here even more remarkable as this was a wet spring/summer. I only needed to irrigate once the entire season. The rains were consistent and moderate throughout the entire growing season and yet the barrier still killed tall grass in as little as two weeks.

The crimping/rolling of the cover crops is usually not enough to have good weed control throughout the season. Using the weed barrier will kill a flush of new weed growth or a thick stand of 1-3 ft tall grass or broadleaf weeds. The weed barrier does not have to sit very long, just 1-2 weeks (1 wk if dry and 2 wks if wet) to create a 'stale' seed bed under the mulch or on the bare ground. It can then be moved to another location in the field for weed control. Once removed, the weed barrier provides 2-3 months of good weed control if there is a cover-crop mulch layer present, if just bare ground the weed control lasts 4-6 weeks, but longer under dry conditions. The weed barrier is not too laborious as one person can move the barriers and set them up again. Mowing weeds on top of the cover crop mulch is another option as this gives good weed control for ~3-4 weeks depending on rainfall amounts - more rain shorter control. And if possible chemicals can be used in place of a physical weed barrier.

Figure 1. Roller/crimper used to kill cover crops for planting no-till vegetables

Figure 2. Best timing for crimping/rolling of cover crops

Figure 3. Results of best timing for crimping of rye/hairy vetch cover crop for no-till sweet corn planting

Figure 4. Weed barrier was laid down for 2 weeks and then moved down the row to cover additional grass weeds

FLUCTUATING TEMPERATURES AND EFFECTS ON BERRY CROPS

Richard Marini, Department of Plant Science, Penn State University

As the climate has been changing, fruit production is becoming more challenging. During the past decade, warmer winters have resulted in inadequate chilling for peaches in Georgia and southern Italy, and pistachios in southern California. In Bordeaux, France grapes are being harvested more than two weeks earlier than in previous decades, leading to changes in wine quality. In Pennsylvania, chilling is not a problem, but during the last decade we have recorded higher than normal temperatures during February and March at our research farm in Centre County. These warm temperatures during the late winter have advanced bloom of some fruit crops by up to three weeks, increasing the likelihood of cold injury before, during and after bloom. In other parts of the country early cold snaps following unusually warm autumn weather has caused cold injury to nursery stock and commercial fruit plantings. As a result of these changes, growers need to understand how plants respond to fluctuating temperatures so they can modify cultural practices to minimize injury.

Before discussing cold injury there are several terms that are important to understand before discussing cold injury. The term "hardiness" can be misleading because it implies that a plant can resist cold temperatures, but there are several aspects of hardiness that need to be considered. "Dormancy" refers to the period in a plant's lifecycle when visible growth in temporarily suspended. The susceptibility of a plant to cold injury varies during the winter, partly depending on its stage of dormancy and the environmental conditions preceding the cold event. There are actually two stages of dormancy. In the late summer, pigments in the leaves perceive short days and the plant enters the first stage of dormancy, called *endo-dormancy*. During endo-dormancy the plant will not grow even when exposed to conditions favorable for growth and this usually occurs before leaf fall. Environmentally-induced gene expression causes structural and biochemical changes within the plant tissues. These changes include increases in growth inhibitors and changes in enzymatic systems, levels of sugars, lipids, DNA and RNA, membrane permeability and tissue hydration. In general these changes protect against dehydration, oxidative damage and other stresses resulting from freezing. After the chilling requirement has been satisfied the plant is ready to grow, but the environmental conditions are not conducive for growth. This second stage of dormancy is called *eco-dormancy*. *Cold* h*ardiness* is a general term that indicates the relative resistance of a plant to low temperature injury. In late summer most berry crops are injured by temperatures around 28°F. At the beginning of endo-dormancy plants can survive temperatures lower than they could during the summer. Upon exposure to the first frost, plants rapidly (within 12 hours) develop additional resistance to low temperatures; after several frosts or prolonged exposure to non-lethal cold temperatures, the plant develops maximum resistance to low temperatures. When plants are in eco-dormancy the plant typically de-acclimates and loses hardiness in response to warm temperatures. If the plants are again exposed to non-lethal low temperatures, they usually have the ability to reacclimate, but often to a lesser extent than preceding the warm temperatures. The ability of a plant to reacclimate depends on the stage of dormancy and the stage of plant development.

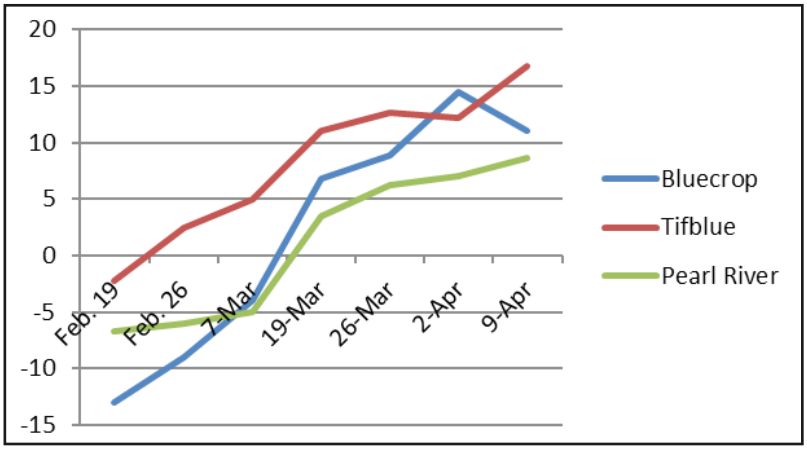
Blueberries

I have seen mid-winter temperatures of about -10°F result in dieback of the more vigorous shoots on highbush blueberries. There are reports of blueberry buds surviving -22°F in mid-winter. However, bud injury can occur at much higher temperatures during the fall and late winter, so ideally we would like varieties that acclimate early, have prolonged periods of endo-dormancy, have the ability to reacclimate in late winter, and bloom late. Blueberry breeders working with the USDA in Maryland and in New Jersey have been studying the genetic control and regulation of acclimation, deacclimation and cold hardiness in blueberry. They have shown that the CDF family of genes (core-binding factor) is involved in acclimation. This family of genes has been implicated in cold tolerance in many plant species and is involved in some types of leukemia in humans. While studying cold hardiness of buds they found that mid-winter hardiness of a given variety can vary by 8 to 12°F from one year to another depending on a number of factors. In late-winter, bud hardiness was related to stage of development but unexpectedly, deacclimation rates were not associated with chilling requirement or mid-winter hardiness.

Several species and interspecific hybrids have been used to study acclimation and cold hardiness to identify breeding material. When five varieties were deacclimated at constant 68°F, those with more rabbiteye (*V. ashei*) in their background generally deacclimated earlier than those with mostly northern highbush (*V. carymbosum*). In late winter the buds of 'Bluecrop' (100% northern highbush) were more hardy than 'Pearl River' (70% northern highbush and 30% rabbiteye) and 'Tifblue' (100% rabbiteye) was least hardy (Fig. 1). However, during March 'Bluecrop' deacclimated faster than the other varieties and was less hardy than 'Pearl River'. By early April 'Pearl River' was the most hardy. Of the 12 varieties tested, 'Duke' (100% northern highbush) deacclimated earliest, 'Legacy' (75% northern highbush) had the least mid-winter cold hardiness, and V. constablaei (the hillside blueberry native to the mountains from Virginia to South Carolina) acclimated latest. Acclimation rate was not very well related to the genetic composition of a variety and 'Bluecrop', 'Ozarkblue', 'Weymouth', 'Tifblue' and 'Legacy' acclimated earliest.

Costante and Boyce (1968) were the first to evaluate blueberry shoot hardiness using controlled freezes to compare the cold hardiness of blueberry varieties. In Burlington, Vermont they found that shoots hardened rapidly between September and October, followed by gradual hardening until January when maximum hardiness occurred. Shoots gradually lost hardiness in February and March, but rapidly lost hardiness between March and April. Of the 20 varieties that they tested, 'Collins' was most hardy, 'Bluecrop' and 'Berkley' were intermediate, and 'Blueray' and 'Stanley' were least hardy in January.

Fig. 1. Flower bud cold hardiness (°F) of three varieties with varying levels of northern and highbush and rabbiteye composition (Rowland et al. 2005).



Raspberry

Cold hardiness in raspberry is probably more complex than for other crops. Raspberry cold hardiness is related to sugar concentrations in the canes and buds. During acclimation starch is converted to sugars and plants or varieties with high sugar concentrations become more cold hardy than those with lower sugar concentrations. Like blueberry, the relative hardiness of canes and buds are not always related. The cambium and phloem tissues are less cold tolerant than buds and xylem. Injury often is apparent as tissue browning at the base of flower buds. If phloem and cambium is injured, but not the xylem, the fruiting laterals usually grow in the spring until nutrient reserves are depleted. In the 1940s Brierly and Landon (1946) published several papers on raspberry cold hardiness at the University of Minnesota. 'Latham' was among the most hardy varieties they tested and although it was introduced in 1920 it is still recommended in northern areas due to its cold hardiness and disease resistance. Field observations indicated that 'Latham' could survive -49°F in mid-winter, but it can be injured by much milder temperatures following warm spells. Raspberry roots are injured when exposed to temperatures lower than -2°F. Reports from Missouri and Minnesota suggest that raspberry endo-dormancy is completed by late October and thereafter the plants deharden in response to warm temperatures. In years with long growing seasons (frost free days) raspberries enter and complete dormancy earlier than in years with short growing seasons. Endo-dormancy is completed earliest in terminal ends, and latest in mid-cane buds. Upon entering eco-dormancy terminal buds lose hardiness during warm weather earlier than buds lower on the cane. This difference in dormancy may be related to immaturity of the tissue or the late-season growth may be physiologically similar to growth produced in short growing season.

Since the chilling requirement for raspberries is satisfied by early December, the canes and buds respond to warm weather during the winter. On sunny winter days the temperature inside the reddish brown canes are higher than the air temperature. On a sunny winter day in South Carolina the temperature under the bark of peach trees was 53° when the air temperature was only 37°F. After the chilling requirement is satisfied, little bud development occurs as long as temperatures remain below the critical temperature of 45°F. Considerable mid-winter hardiness was lost after two days at 43 to 45°F. In a Minnesota field trial, 66% of the length of the canes was injured by cold following four consecutive warm days and canes were killed entirely following eight warm days. In fact 'Latham' canes deac-

climated following just four hours at 39°F, and 27°F was needed to maintain hardiness. Peach flower buds were also shown to deacclimate when exposed to temperatures above 28°F. So 43°F may be the critical temperature for visible bud development, but temperatures near freezing are required to maintain cold hardiness.

Strawberry

Strawberry is an herbaceous perennial and it lacks the cold hardiness of the deciduous woody berry crops. The only reason strawberries can be grown in Pennsylvania is because the plants can be protected with mulch and snow to avoid exposure of the crowns to low temperatures. During the fall strawberry plants acclimate from about 27°F in early September to about 8°F, but flower buds may be damaged at 15°F. Brierly and Landon (1944) reported that well-hardened plants were injured at 21°F and killed at 10°F. Acclimation is associated with increases in enzymes involved with anti-oxidation, de-toxification and disease resistance compounds. Proteins associated with pigment biosynthesis are produced and result in increased carotenoids and flavonoids in the leaves.

Unlike other berry crops, where cold injury often occurs during early or late winter, mid-winter low temperatures are usually responsible for injury in strawberries. During the autumn it is important to delay mulching until the plants have been exposed to short days and below freezing temperatures to allow the plants to acclimate. Research in Vermont showed that delaying mulch application just two weeks, from October 29 after 5 days below 32°F, until the plants were exposed to 11 days of freezing temperatures on November 12 resulted in a 20% increase in yield the following season. Mulching too early prevents leaves from intercepting light and this reduces photosynthesis and also prevents the leaves from perceiving short days. In addition, early mulching prevents plants from being exposed to freezing temperatures required for the development of maximum cold hardiness.

Strawberry varieties differ in their acclimation rate and maximum mid-winter hardiness. Research in Quebec showed that 'Hecker' was 2°F less cold tolerant than 'Tristar' or 'Redcoat' throughout the acclimation process. Fruiting everbearing cultivars during the fall also reduced the concentrations of nitrogen, starch and sugars in the crowns and reduced cold hardiness by 2°F in October. In a Minnesota variety trial, 45% of nonmulched 'Sable' and 'Brunswick' plants survived the winter, whereas 'Honeoye' and 'LAmour' had 23% survival and only 2% of the 'Clancy' plants survived.

Boyce (1967) studied various aspects of cold hardiness of 'Catskill' plants by freezing crown tissue and measuring electrolyte leakage. This technique is based on the theory that low temperatures injure cell members and solutes leach out of injured tissues; the concentration of leachates is related to the level of injury. Although in the field, crowns are rarely exposed to temperatures drops lower than 2°F/hour, he found that rapid freezing at 10°/hour caused more injury than slower freezing. The rate of thawing did not affect injury, but the length of time tissues were exposed to freezing temperatures did affect injury. One hour at 24°F caused more injury than one minute and injury continued to increase as tissues were exposed to freezing temperatures for up to five days. During Vermont winters with no snow, strawberry crowns in the field are sometimes exposed to temperatures below 20°F for up to six days. Repeated freezing and thawing also caused increased cumulative injury; exposure to 20°F for one hour followed by two hours at 40°F, followed by exposure to 20°F for one hour caused more injury than a single cold exposure. Exposing dormant plants to 70°F in the greenhouse for one day caused little deacclimation, but exposure to greenhouse conditions for two days caused plants to deacclimate and deacclimation progress as plants were exposed for up to seven days of warm temperatures.

My master's research involved evaluating the effects of cold injury on growth and fruiting of 'Catskill' plants. Plants growing in pots were removed from the field in late fall and were placed in cold storage until being exposed to a range of freezing temperatures in a freezer. After thawing slowly for six weeks in cold storage, the plants were grown in the greenhouse. The severity of cold injury can be assessed by cutting longitudinally through the crown to observe tissue browning. The tissue in the center of a crown is called the medulla or pith and is composed of parenchyma cells that contain starch (Fig. 1). Browning in the lower portion of the medulla indicates slight cold injury, and as injury becomes more severe the browning extends upward and becomes darker in color. When about half of the medulla is brown we can expect that some of the flower buds have been killed. As long as the vascular tissues that form

a cylinder around the medulla are white, the plant will survive, but growth may be affected. For 'Catskill' I found that leaf production was slightly reduced by exposure to 24°F, at 17°F there was medulla browning, about 5% of the plants were killed, some blossoms were killed and plants produced more runners. About half of the plants were killed by exposure to 14°F and leaf size and the dry weight of the plants were reduced at 10°F.

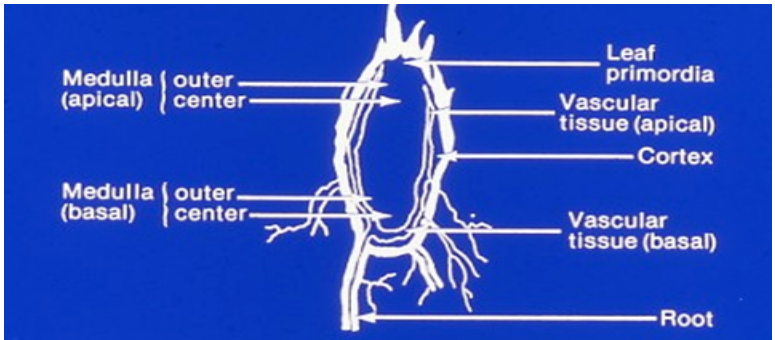


Fig. 1. Diagram of a longitudinally cut strawberry crown, showing tissues evaluated for TTC reduction and oxidative browning. Drawing adapted from Darrow (4) and White (12).

Research aimed at understanding cold hardiness of berry crops has not been performed in enough detail to understand intensity and rapidity to which berry crops respond to periods of warm and cold temperatures inducing deacclimation and reacclimation. In the 1950s and 60s researchers at Washington State University studied the daily changes in peach flower bud hardiness and found that there can be a dramatic response to changes in air temperatures especially during the later stages of bud development. When exposed to temperatures below 28°F during late winter the hardiness of flower buds could increase 1 to 3°F per day and temperatures above 28°F can reduce hardiness by 1°F per hour (Proebsting, 1970). Berry crops likely respond to fluctuating temperatures in a similar manner.

Strawberry flowers are also able to acclimate. When I was a student at Vermont we noticed that flowers on the everbearing variety 'Ozark Beauty' survived a fall frost that should have killed the flowers. The next spring I froze flowers of several varieties, including 'Ozark Beauty' in a freezer at various temperatures and found that all flowers were killed at 28°F. That fall I froze 'Ozark Beauty' blossoms at weekly intervals and found that before plants were exposed to near freezing temperatures the flowers were killed at 28°F. However, upon being exposed to a nonlethal frost of 30°F the killing temperature declined to 24°F. This ability of blossoms to acclimate explains why blossoms sometimes survive frosts that we think should be lethal.

Summary

We can't control the temperatures that injure our crops, but there are cultural practices that can encourage proper acclimation and the development of cold hardiness. It is important to prevent the plants from being stressed during the late summer and fall. Over-cropping is a stress and can also lead to reduced cold hardiness. In several peach experiments I observed lower flower bud survival on trees that were thinned late and on trees that carried heavy crops previous summer.

Maintaining adequate plant nutrition and avoiding drought stress will also allow plants to acclimate properly. Anything that prolongs vegetative growth during the late summer, such as summer pruning or nitrogen application can delay the acclimation process. In the 1980s, while studying summer pruning of peaches I found that pruning in mid-August delayed leaf drop in the fall and delayed acclimation resulting in less hardy flower buds in November. Since sugars are important for acclimation and cold hardiness, it is important to maintain healthy leaves during the late summer and fall. Avoid pruning until late winter and before the prediction of cold events. There is quite a bit of antidotal evidence that pruning fruit trees early in the winter will temporarily reduce the cold hardiness of the tree. There is research with other woody plants that support these orchard observations. Pruning just before bloom can also reduce the cold hardiness of flower buds. One year I pruned some peach trees that were in pink, but I was

unable to prune all the trees until a few days later. We had a frost after I pruned the first trees, but before I pruned the other trees. During bloom more than half of the flower buds on the trees that were pruned before the frost were dead, but none of the buds of the later pruned trees were killed. Unfortunately, methods to prolong dormancy and delay bloom have not been identified, so it is important to plant varieties that are known to survive Pennsylvania winters and that bloom late.

Literature Cited

Boyce, B.R. and C.R. Smith. 1967. Low temperature crown injury of dormant 'Catskill' strawberries. Proc. Amer. Soc. Hort. Sci. 91:261-266.

Brierly, W.G. and R.H. Landon. 1946. Some relationships between rest period, rate of hardiness, loss of cold resistance and winter injury in the Latham raspberry. Proc. Amer. Soc. Hort. Sci. 47: 224-234.

Costante, J.F. and B.R. Boyce. 1968. Low temperature injury of highbush blueberry shoots at various times of the year. Proc. Amer. Soc. Hort. Sci. 93:267-272.

Proebsting, E.L., Jr. 1970. Relation of fall and winter temperatures to flower bud behavior and wood hardiness of deciduous fruit trees. HortScience 5:22-24.

Rowland, L.J., E. L. Ogden, M.K. Ehlenfeldt, and B. Vinyard. 2005. Cold hardiness, deacclimation kinetics, and bud development among 12 diverse blueberry genotypes under field conditions. J. amer. Soc. Hort. Sci. 130:508-514.

MANAGEMENT OF SPOTTED WING DROSOPHILA ON DIVERSIFIED SMALL FRUIT FARMS: AN UPDATE

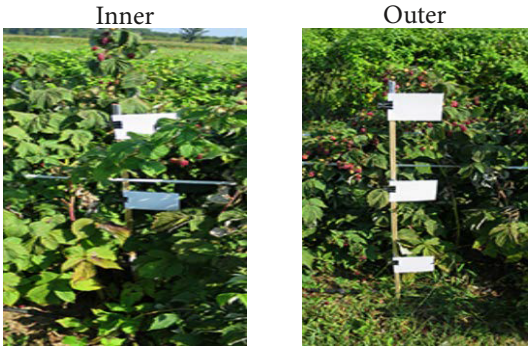
Arielle Arsenault-Benoit, Margaret Lewis, Bryan Butler, Christopher Taylor, and Kelly Hamby
University of Maryland
4112 Plant Sciences Building
College Park, MD 20742
kahamby@umd.edu

Spotted wing drosophila (SWD) is an invasive insect pest that continues to be a serious problem for growers of soft-skinned fruit. Mid-Atlantic diversified small fruit farms often plant multiple crops that are suitable hosts for SWD, and also extend the harvest period for those crops by planting multiple varieties. Therefore, these farms have susceptible fruit available for SWD for a large portion of the growing season. SWD populations can build up quickly, arrive from surrounding forested refuges, and cause significant economic damage. Management of SWD is challenging and labor-intensive. Currently, pesticides are the predominant management strategy, and sprays are most effective when they directly contact the adult flies. Frequent sprays are often required. Also, many host plants, such as blackberries and raspberries, have dense foliage that may provide refuge from sprays. Spray coverage should be optimized to ensure the best control occurs, and alternative management strategies are needed.

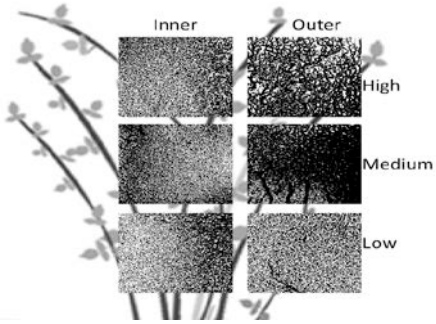
Spotted wing drosophila can become stressed under high temperature and low humidity conditions. When stressed, SWD develop more slowly, don't reproduce as well, and may die. Cultural controls aim to manipulate the environment to make conditions more unfavorable for pests and are an important component of the Integrated Pest Management (IPM) toolbox.

We are exploring multiple methods to enhance management, including optimization of sprays and the development of cultural controls. Studies were conducted in 2016 and 2017 at the Western Maryland Research and Education Center (WMREC), Keedysville, MD and the Wye Research and Education Center (WYEREC), Queenstown, MD.

A



B



Optimizing Spray Coverage Spray coverage impacts the efficacy of chemical controls. The characteristically dense foliage in caneberries impedes spray dispersal through the plant, creating areas with poor coverage where SWD may refuge. We hypothesized that a higher spray volume, generated through increased carrier water, may aid in dispersal of sprays through the plant. For this study we considered both carrier volume and the spatial dispersal of sprays. In 2016 and 2017, we evaluated spray coverage in fall bearing blackberries and raspberries using an airblast

Kelly Hamby is an Assistant Professor and Extension Specialist in the Department of Entomology at the University of Maryland. Her research and extension program addresses invasive and emerging insect pest issues, evaluating and optimizing pest management programs, and development of sustainable alternative management tactics, primarily in small fruit and grain crop systems. She received her B.S. in Environmental Toxicology, M.S. in Entomology, and Ph.D. in Entomology at the University of California Davis.

orchard sprayer. White spray cards were deployed in the inner and outer canopy at three heights and spray coverage was visualized at two carrier volumes (50 and 100 gallons per acre (GPA)), by adding a pink marker dye to the tank mix (Fig.1). The percentage of the card dyed pink was calculated using ImageJ software. Results for raspberries are presented here. In 2016, increased carrier water increased spray coverage in the outer canopy, whereas in 2017, increased carrier water increased spray coverage in *both* the inner and outer canopy (Fig. 2). At WMREC in 2017 raspberries, percent coverage (averaged across all heights and spray volume treatments) was 32.4% ± 4.4% (mean ± standard error) in the inner canopy, compared to 45.9% ± 5.2% in the outer canopy. Coverage rates in WMREC raspberries demonstrated some variation by canopy height, and in 2017 this only occurred in the inner canopy. In 2017 with the 100 GPA spray volume, we observed a significant increase in spray coverage rates throughout the entire raspberry canopy across two field sites, compared to 50 GPA spray volume. Spray coverage results were somewhat inconsistent, and are likely the artifact of many variables, including the configuration of the sprayer, and the density and health of the plants. Additional factors that can affect spray coverage include making sure nozzle configuration is appropriate for the crop you are spraying and avoiding application of water-soluble pesticides on days immediately following or preceding periods of heavy rain. Increasing carrier water volume may be more time consuming, but there is evidence of more effective and well-dispersed spray application at 100 GPA. Caneberries can fruit low to the ground, and some studies suggest that SWD density is high in the lower canopy, so it is crucial to configure the sprayer to cover this area, which is easily missed with an airblast sprayer. The dense foliage at the center of the canopy and low to the ground may act as a refuge for SWD against sprays and the elements, so efforts to reach these areas with chemical controls will likely improve the success of management efforts.

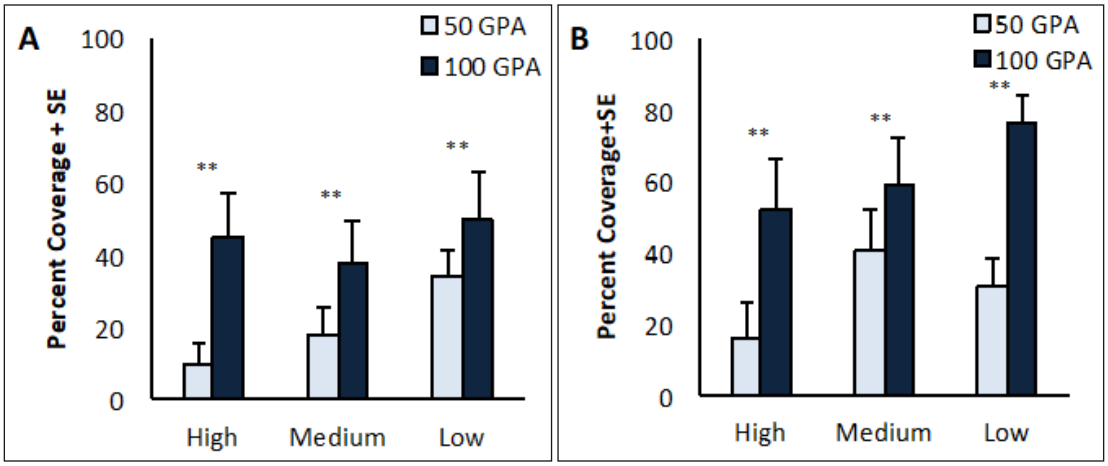


Figure 2. Average percent coverage + standard error in red-raspberries sprayed with an airblast sprayer at Keedysville at two carrier water volumes in the (A) inner and (B) outer canopy at three different heights in 2017. Coverage rates significantly improved when sprays were applied using the 100 GPA rate.

Cultural Controls: Mulching and Pruning In addition to our efforts to optimize spray volume, we considered cultural management practices that can be integrated into either conventional or organic management systems. Specifically, mulching and pruning of host plants can alter the local environment, generating unfavorable conditions for pest development and survival. We evaluated the impact of woodchip mulch and woodchip mulch covered in fabric weedmat on SWD development at different life stages. Throughout the blueberry fruiting season temperatures were recorded above the mulch as well as ~1" below the mulch of each treatment plant. Temperatures above the mulches were highly variable, often approaching or exceeding 120°F. Mulch treatments impacted the regularity at which temperatures exceed 87°F, the temperature where SWD starts to exhibit heat stress. Laboratory infested blueberries and early-stage pupae from the laboratory fly colony, were bagged and placed either above or below the mulch treatments at each site, and left for one week (Fig. 3). A week later, adult survival was evaluated. In all cases, temperatures above the fabric were as hot or hotter than above the woodchips. It is also warmer below the fabric than below the mulch, and better SWD survival corresponded to the cooler temperatures below the woodchips. In most replicates of the two-year study, zero or very few individuals survived above either type of mulch. Flies starting in the field as pupae survived better than those starting as eggs and in 2016 the mulch treatment was better for pupal survival.

Pupae likely survive better because they have fewer developmental stages to complete and the pupal casing is protective. The fabric weedmat may be an effective strategy because not only does it create more sustained hot conditions, but it is also a physical barrier between the plant and the more favorable environment below the mulch.

Figure 3. Examples of treatments deployed in the mulching study.

2016, pruning impacted the number of hours the temperature exceeded 87°F at WMREC, the site where we saw significant differences in canopy density. Pruning also impacted infestation at this site, with significantly higher average larvae per berry in the denser and cooler no-prune treatment than the medium or high prune treatments (Fig. 4). At WYEREC, canopy density and climatic factors were not significantly different between treatments, and there was no significant difference in larvae per berry. Pruning can impact overall yield, and at WMREC, where canopy density differed, we saw significantly higher yield in the high density, no prune treatment (Figure 4). Considering infestation was also higher in this treatment, future analyses will consider the impact on marketable yield compared to cull to determine whether the reduction in yield can be made up with higher *quality* yields in the low-density, high prune treatments. An economic analysis will also consider the increased pruning labor associated with this approach. Analysis of 2017 data is ongoing.

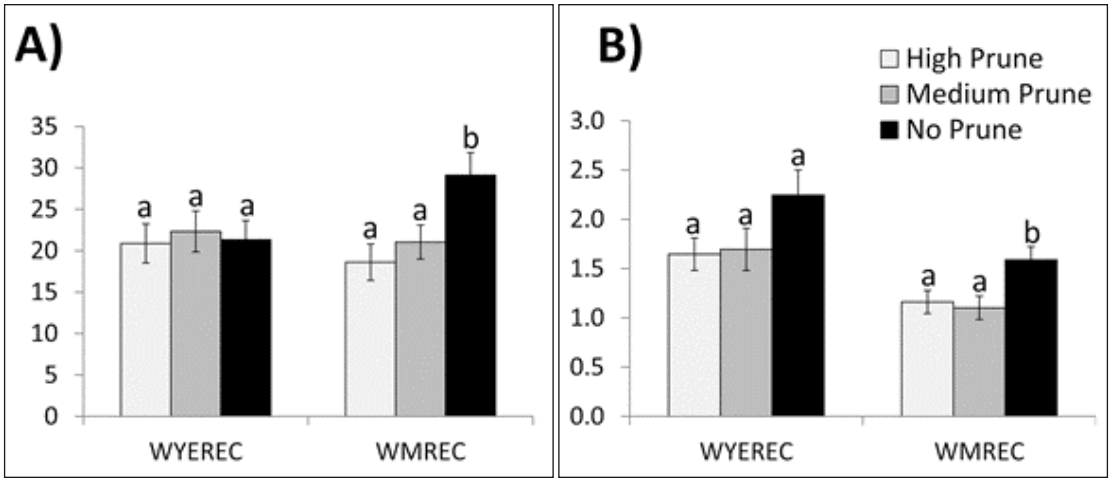


Figure 4. Effects of pruning on yield and infestation in raspberries, 2016. A) Mean weekly total yield by site. B) Mean larvae per berry by site. Letters indicate differences by treatment.

<u>*Conclusions*</u> In raspberries, we observed better spray coverage in the outer plant canopy relative to the inner canopy, because their thick foliage limits pesticide dispersion to the center of the canopy. The results from this study suggest that using a higher carrier water volume can improve spray coverage in raspberries; however, raspberry plantings with thicker canopies or different types of trellising may respond differently to the increased carrier water volume. Addition of cultural controls can also be beneficial. Black fabric weed mat tends to sustain hotter temperatures longer, and additionally, it acts as barrier between the plant and the mulch. Whether SWD pupates within the fruit or falls to the ground to complete development, it is likely easier for them to get below the mulch, where conditions are more favorable for survival, when plants are mulched only with woodchips. Pruning can impact canopy conditions, but we were not always able to prune enough to see this effect. SWD infestation is only impacted when the canopy is significantly thinned and conditions in the canopy are changed, which also reduces yield. Therefore, an economic analysis must also be considered before we recommend producers try it.

Acknowledgements: These projects were supported by funds from Maryland State Horticultural Society and the Maryland Department of Agriculture 171501-05, NIFA OREI 2015-07403 and Maryland Agricultural Experiment Station (MAES). Special thanks to our grower-cooperators, staff at WMREC and WYEREC, Garrco Products Inc, Galen Dively, Doug Price, and all members of the Hamby Lab.

IMPROVING FRUIT ROT MANAGEMENT BY PREVENTING FUNGICIDE RESISTANCE DEVELOPMENT

Justine Beaulieu, Bryan Butler and Cassandra L. Swett
University of Maryland
2176 Plant Sciences Building
College Park, MD 20742

Botrytis fruit rot (caused by *Botrytis cinerea*) and Anthracnose fruit rot (caused by *Colletotrichum acutatum*) can both be devastating diseases of strawberries, as well as other crops (e.g., blueberries, raspberries, and apples) in the Mid-Atlantic. These diseases can come into strawberry fields in infected plant material (nursery stock) and can persist in soil debris and on alternate hosts. The pathogens infect strawberry flowers in the spring when there is high moisture and moderately cool temperatures; in the case of BFR particularly, the disease is favored if blooms are frost-killed and plants are at a high density. The pathogens produce spores on diseased fruit, which can rapidly spread (within about four days) to infect new ripe fruit, causing rapid secondary spread; about 90% of infections in a field are from this secondary spread.

The best management practice to control fruit rots and avoid secondary spread is to prevent early season flower and fruit infections. Infected fruit should be removed during and after harvest. At planting, the use of plastic mulch can prevent soil inoculum from contacting fruit. Frost damage to flowers should be prevented by using row covers, later blooming varieties, and wider spacing. In organic production, single row planting is recommended. In conventional production, fungicides are an effective way to protect blossom and fruit infections. Applications should start at 10% bloom and the most effective compounds should be used during peak bloom to prevent flower infections. For BFR, the most effective fungicides to apply at bloom include Switch and Elevate; post bloom sprays can include Elevate, Kenja, Fontelis, Luna Tranquility or Luna Sensation. For CFR, Abound, Cabrio and other strobilurin-based compounds, as well as the above, are effective. These can be tank mixed with Captan, Thiram or OSO/Tavano/PhD (polyoxin D) to enhance treatment efficacy.

Fungicide efficacy is at risk for both of these diseases. Strobilurins such as Pristine are no longer recommended for BFR control due to widespread resistance development (Figure 1) and, in some regions (e.g., Florida), are losing efficacy for AFR as well.

Justine Beaulieu is a Faculty Assistant at the University of Maryland. Half of her position is dedicated to food safety education and the other half is dedicated to plant pathology research. She has a Bachelor of Science in Environmental Science and Policy and a Master of Science in Plant Sciences from the University of Maryland. She is a Maryland native, having grown up in Montgomery County. She has worked for the USDA ARS in the past and served as a Peace Corps Volunteer in the South Pacific for two years. In her free time, she enjoys spending time with her fermentation club and sings in a local community choir.

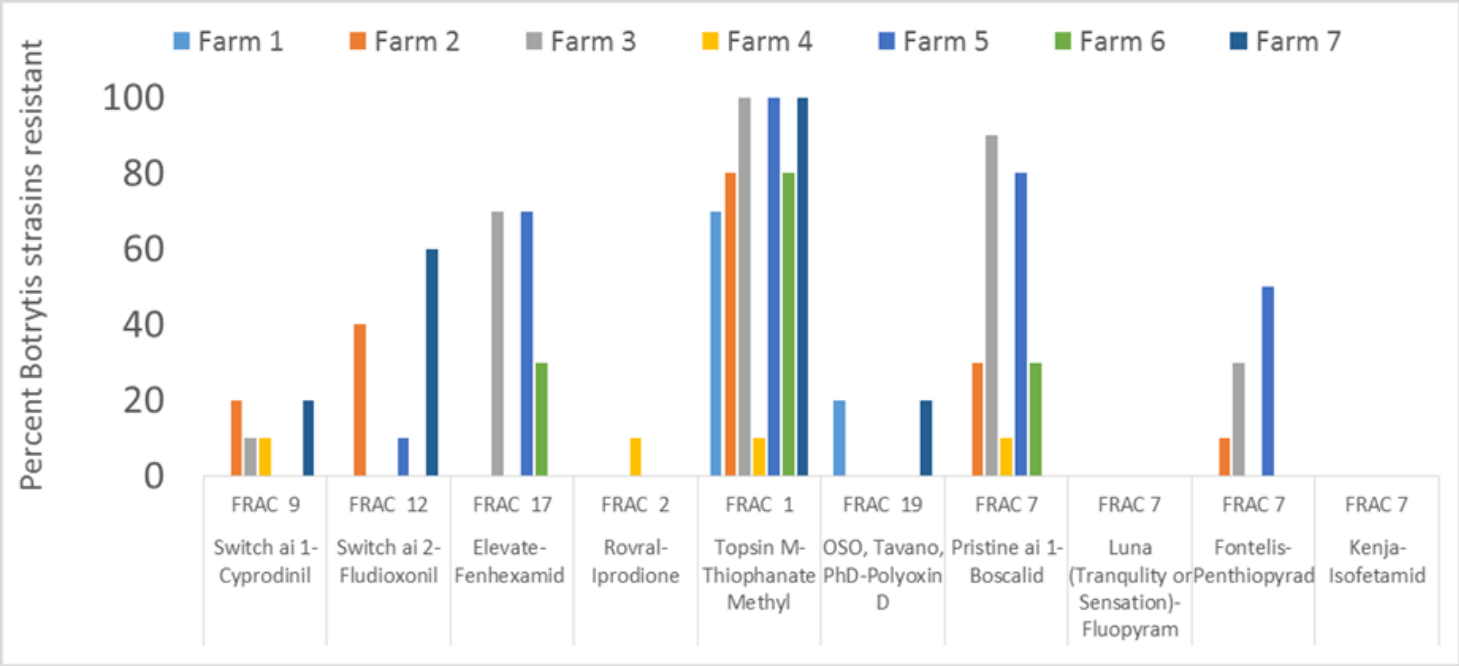


Figure 1. Fungicide resistant populations of Botrytis on Maryland farms, based on 2016 testing (Guido Schnabel).

To prevent fungicide resistance from developing in the pathogen, it is critical to rotate fungicides with different modes of action (FRAC groups) and to avoid overuse of our best products, such as Switch.

Reducing the total number of fungicide applications can greatly assist in fungicide resistance management. Applications can be reduced by applying only when there is a disease risk, rather than on a calendar-based program. Disease risk can be determined based on weather conditions—the fungus will only infect the plant when it's above 55°F with at least 12 hours of leaf wetness. There is currently a forecasting system which can evaluate the risk of these two diseases in strawberry, called the Strawberry Advisory System (SAS). SAS was developed in the Southeast and does not extend as far as the Mid-Atlantic states and efficacy in this region is unclear.

In 2016 we extended the SAS system to Maryland to evaluate the efficacy of the model-based spray program in controlling disease in Chandler. This work was conducted in 2016 and 2017 at an experiment station in western Maryland. Chandler was planted on plastic mulch and disease was evaluated under three treatments: i) Cover=weekly Captan spray; ii) SAS=Captan spray based on risk; and iii) Water= no spray (control).

2016 was a very wet spring; SAS saved one out of six sprays. Botrytis and Anthracnose fruit rot were both controlled equally well in the SAS as the cover treatment, and there was no difference in the percent of fruit that were marketable (Figures 2 and 3). Fruit biomass was lower in the SAS treatment, but not significantly. 2017 was a much drier spring and SAS saved four out of five sprays. BFR and AFR levels were very low in all treatments (< 2%) and were not different between treatments (Figure 2). Marketable yields also did not differ between treatments (Figure 2). In addition, in 2016, both SAS and the cover spray reduced sap beetle infestation by 50%; sap beetle and Anthracnose fruit rot incidence were positively correlated, suggesting that control of Anthracnose fruit rot might also serve to control sap beetles (Figure 4).

Over the two years, SAS has accurately predicted and provided protection for both Botrytis and Anthracnose fruit rot and adapted our fungicide program to reduce the number of applications in both years. Based on our work in this and other regions, SAS should only be used after the final row cover removal; as long as row covers continue to be employed, a calendar-based spray program is most advisable.

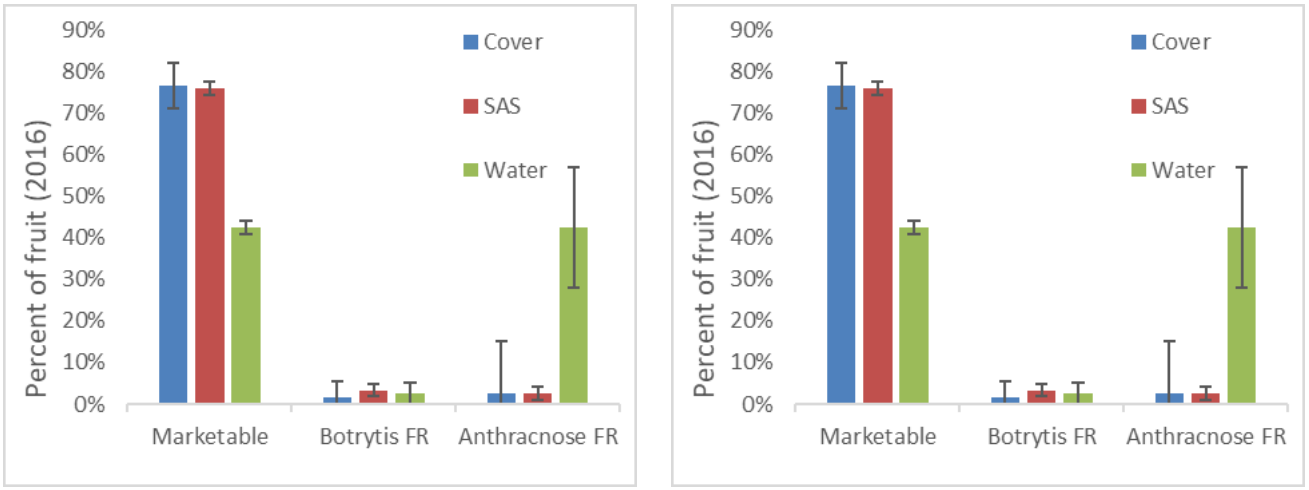


Figure 2. Percent of marketable and diseased Chandler fruit under Cover, SAS and Water in 2016 (Left) and 2017 (Right).

Figure 3. Percent of marketable Chandler fruit under Cover (Left), SAS (Middle) and Water (Right) in 2016.

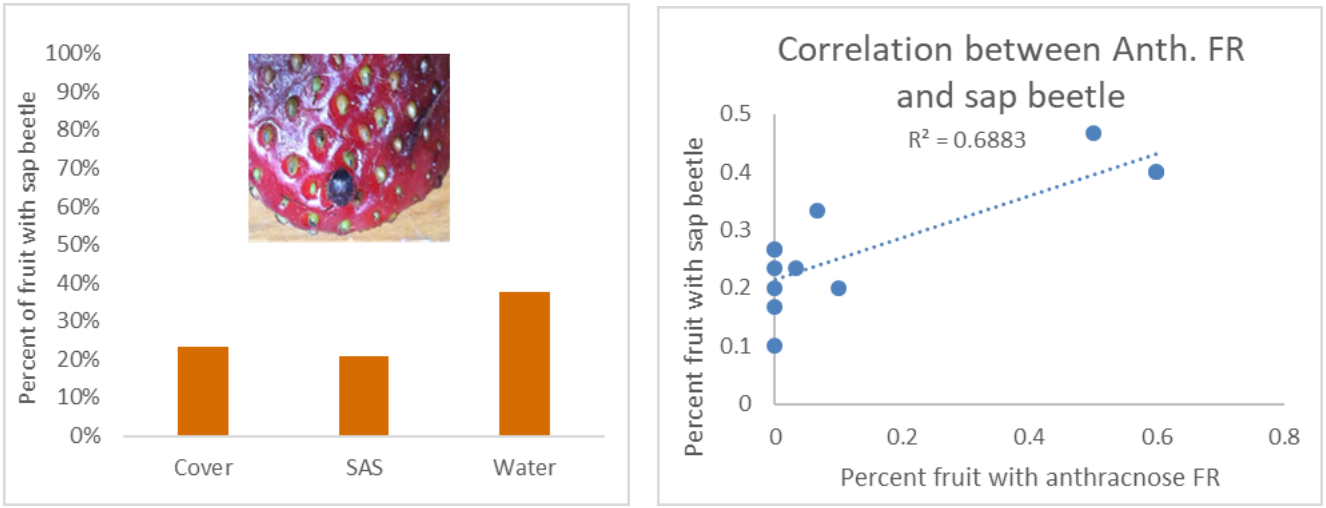


Figure 4. Effect of fungicide treatments on sap beetle (Left) and correlation between anthracnose fruit rot and sap beetle incidence (Right).

STRAWBERRY PRODUCTION IN CONTAINERS – TIPS FOR SUCCESS

Kathy Demchak
Penn State Univ., 102 Tyson Bldg., University Park, PA 16802

Production of strawberries (usually day-neutrals) in containers is something many growers try at one point or another for logical reasons. Strawberry plants are small, and especially if you are growing them on expensive real estate or in a high tunnel system, it seems that production per square foot could go up a lot - if we could just figure out how to squeeze more plants into a given space! In addition, issues with soil-borne diseases and rotations in field soil, or just the desire for more control over what happens with the plants, adds to the appeal of containerized production.

Many have tried, often using fairly complicated and expensive set-ups with disappointing results. What does to be successful? It all comes down to a few simple basics, and understanding the plants' needs. By following a few basic rules, the chances for success can be greatly increased.

Use the Right Media. Many different types of media have been recommended over the years, ranging from extremely well-drained inorganic media such as pure perlite for hydroponic systems, to organic renewable media such as coir, to media that is much finer in texture. The bottom line is that growing in containers gets a lot easier if you use a media that has a good combination of sufficient drainage and water-holding capacity. A few years back, we set up an experiment in grow-slabs (shallow sleeves filled with media), and comparing coconut coir, Metromix 360, a 2:1 mixture of peat:coarse perlite, and a 2:1:1 mix of peat:perlite:coir. By far the 2:1 mix of peat:perlite performed best. There are commercial 60:40 peat:coarse perlite mixes, and I'm sure these would work well, too. Most have dolomitic lime added to them. Ours didn't, as our water is high in bicarbonates and tends to raise the pH of the media, so we didn't want the added lime. When we removed the plants from the sleeves to measure the root systems, the treatment sleeves with the 2:1 peat:perlite mix were completely crammed full of roots. That wasn't the case with other types of media. This doesn't mean that this is the only type of media that will work, but it was one that was nearly foolproof for us.

Use Sufficient Container Depth. While it takes some additional media, containers that are at least 6" deep provide more buffering capacity against overwatering and underwatering than more shallow ones, as the plants roots either stay above the saturated media if overwatered, or some moisture can be pulled from below as needed. Studies from Florida found that the deeper the containers were, the better strawberry plants performed, presumably for these reasons. Shallow containers – 4" deep or less, don't allow for much margin of safety when watering plants. It's very easy to overwater them, and they also don't provide much water-holding capacity. Strawberries can take up and transpire a significant amount of water quickly, especially under windy conditions.

Provide Consistency in Soil Moisture and Drainage. Managing the plants is easier if your setup ensures that the plants will all have an equal amount of available moisture. This is part of the difficulty in managing plants that are in a trough where water might pool if there are dips, or in a vertical tower where water in one pot drains through to the next. Once we started growing in individual gro-bags, each with their own dripper, irrigation management got a whole lot easier and the plants grew better. Still, there were a few plants that were in low spots where water tended to pool, and these were the ones that grew poorly compared to the others. There are other options that could work well as long as the water drains from the containers well.

Manage Salt Levels. Perhaps part of the reason for our poor results with coir was high salt levels, which coir tends to have. We flushed the coir with water before planting, but perhaps it could have used more.

Kathy Demchak has been at Penn State since 1983, working first in the area of vegetable and tree fruit nutrition and later in berry crops. Recent research projects have included work on blueberry cultivar evaluation, blackberry cultivar evaluation and cold-hardiness, high tunnel production of strawberries, raspberries, and blackberries, and day-neutral strawberry production. She earned a B.S. in Horticulture from Penn State and an M.S. in Horticulture from Virginia Tech. She happily lives in a rural area of Centre County, with husband Jeff, and sons Tim and Jeff.

Regardless of media, most people who water with drip systems recommend that 25% of the solution drain from the containers, and attribute a portion of the poor performance of lower levels in vertical systems to accumulation of salts there. Strawberries are extremely sensitive to salts, so if the plants look like the edges of the leaves are burned, the problem could be insufficient watering and drought stress, or if the plants seem to have enough water, the problem could be salt injury.

Avoid Hot Root Temperatures. We've had some nutrient problems that we just couldn't seem to solve when growing plants off the ground during the heat of the summer, which miraculously cleared up as soon as temperatures cooled in the fall. The explanation is still a bit of a mystery, but could have been due to the fact that strawberry roots are sensitive to high temperatures - in one study, being killed at temperatures above 86 degrees F. That seems hot, but is within the range of temperatures that roots can experience when the containers are suspended off the ground, especially if the media doesn't provide much buffering of temperatures. We've had better success growing the plants at ground level.

Provide Even Light Levels. This is thought to be a major reason for the poor performance of vertical systems in the northern U.S. if the stacks of tunnels are too close to each other, thus shading the lower plants. However, this could also cause an interaction with moisture levels, as plants receiving less light and transpiring less in the lower levels also use less water, contributing to overwatering of lower levels.

Manage Fertility. We've used several different soluble fertilizers, all delivering 100 ppm N as a constant-feed source of nutrients. Our water is high in bicarbonates, and we found that fertilizers made for our bicarbonate waters helped greatly in avoiding precipitation and micronutrient issues. There are other fertilizers specific for berry crops that tend to keep the pH lower, and these would be expected to work well also.

Plant Early Enough. Getting the plants off to a good start before the heat of summer, and when transplant vigor is still high, results in increased yields over the course of the season.

While this may seem like a lot to consider and manage, most facets are relatively easy to accomplish – IF growing in containers is something that you think you would like to try. Whether profits can be made depends on markets and yields of course, but getting yields to consistently high levels is the first step in increasing the chances of doing so.

INTEGRATED MANAGEMENT OF BLACK ROOT ROT COMPLEX AND CROWN ROTS OF STRAWBERRY

Mahfuzur Rahman, West Virginia Extension

Black root rot complex (BRRC) and crown rot diseases of strawberry caused by multiple soil-borne fungi can severely affect plant vigor and productivity if strawberries are replanted on the same land or maintained in a perennial production system. If planted in contaminated soil, loss in plant vigor with occasional transplant failure becomes evident within a few months of planting, and plant mortality elevates during harvest, especially under conditions of environmental stress. In a perennial production system, disease severity increases each year, leading to increased yield variability within a field and eventual loss of productivity. Although a few fungal pathogens and nematodes have been implicated with black root rot syndrome, *Rhizoctonia* spp. and *Pythium* spp. are well documented as causal agents while additionally *Colletotrichum gloeosporioides*, *Phytophthora cactorum* and *Fusarium* spp. infection can quickly move to the crown inciting crown rot and plant wilting. Lesion nematodes may predispose roots to infection by black root rot-causing fungi to develop black cortical lesions that may girdle the whole root resulting in loss of root function and mass giving the root a rat-tail appearance (Fig. 1). For 'You-pick' strawberry production, growers prefer to grow strawberries in suitable plots (visible from the main road or easy to access) year after year. As a result, soil borne pathogen populations build up over time causing significant disease problems and yield reduction. This problem is usually many-fold higher for growers who utilizes perennial matted row system with limited crop rotation options. Thus, much of the U.S. strawberry industry was dependent on the use of soil fumigation with methyl bromide (MeBr) to effectively manage these soilborne diseases. With the phaseout of MeBr, producers have shifted to the use of other fumigants, but this has led to increased crop losses to soilborne diseases mentioned above. However, soil fumigation benefits are often short-lived as the black root rot pathogens are frequently reintroduced on the roots and crowns of transplants, emphasizing the need for treating/keeping plants infection free starting with the nursery-produced planting stock. Furthermore, increasing restrictions on alternative synthetic fumigants due to health and environmental concerns make the development of effective reduced/non-fumigant based disease control options critical for the economic survival of this specialty crop production system. Potential options for sustainable management of BRRC and crown rot include the following: -

1. Rotation is the first line of defense: growers should try their best to select a new piece of land for each new planting. Strawberry black root rot problem is somewhat similar to apple replant disease (also known as 'sick soil syndrome'), a malady that manifests itself when susceptible plants are placed into soil previously occupied by a related species.
2. Beneficial microbes: pre-colonize plant root system with beneficial microbes that will boost plant vigor and keep the harmful microbes at bay. There are quite a few commercially available products such as Serenade, Terragrow etc. that can be applied by many different ways. Strawberry plug plant producers can treat tips and planting mix with the product suspension before plug setting. Fruit growers can dip plug or bare root plants root system in product suspension overnight before planting to facilitate root system colonization. Preliminary results from our study show that probiotic bacteria treated strawberry plants have higher vigor and less root disease.

Dr. Mahfuzur Rahman is an Associate professor and plant pathology specialist at WVU Extension Service. He received his M.S. in plant pathology from Oregon State University, Ph.D. in plant pathology from Simon Fraser University, Canada and conducted post-doctoral research at North Carolina State University. He conducts applied research for plant disease management and provides leadership for statewide educational/informational programs in plant pathology in WV. He serves as the Director of WVU plant diagnostic clinic and state liaison for National Plant Diagnostic Network (NPDN). 17

3. Biofumigation: biofumigation of plots with high glucosinolate containing mustard cover crop such as 'Caliente 199' or mustard meal can provide both microbial suppression as well as adding organic materials into the soil. If biofumgation cover crop is grown to optimum stage (up to 10% flowering), and tissues macerated by flail mower or some other methods followed by immediate (within half an hour) incorporation into the soil, can suppress soil fungi and nematodes in addition with increasing soil biomass. It is important to follow the maximum tissue maceration, immediate incorporation in moist soil and covering with plastic tarp to block gas for up to 10 days to obtain the best result.

4. Anaerobic soil disinfestation (ASD): ASD on selected plots can be done in three steps. Incorporation of organic material to provide C source to activate soil microbes. Among the options for providing C source are rice bran @ 8 tons/acre, mustard meal@ 1 ton/acre or any legume or grass cover crop biomass. These C sources are usually mixed with the soil with a walk behind rototiller or suitable tilling machine, and then covered the area with oxygen impermeable tarp. In the third step, soil is irrigated to saturation to create anaerobic conditions and stimulate the anaerobic decomposition of incorporated organic material and enhance diffusion of by-products in the soil. Accumulation of toxic/suppressive products deriving from the anaerobic decomposition (e.g. organic acids, volatile organic compounds) kill pathogenic microbes. This process usually takes at least 3 weeks to be completed. While this process has technical components involved, studies in CA, FL and other countries produced promising results for high value crops such as strawberry and tomato. In some cases, results were comparable with synthetic fumigants.

Fig. 1. Healthy root system (left) with many white roots and a healthy network of fibrous roots. Roots affected by Black root rot (right) have a poor fibrous root structure, are black or have many brown lesions, and take on a "rat-tail" appearance (photo credit: Frank Louws, NCSU)

BIRD DAMAGE IN BLUEBERRIES – RISK FACTORS AND MANAGEMENT STRATEGIES

Catherine Lindell
Michigan State University Department of Integrative Biology and Center for Global Change and Earth Observations, 1405 S. Harrison Rd., East Lansing, Michigan 48823, lindellc@msu.edu

Risk factors for crop damage by birds

General Principle 1…When there is less fruit in a given area, there will be a higher proportion of damage to the crop that is available. One should expect higher proportions of damage in: 1) low-yield years, 2) early-ripening varieties, 3) small blocks.

General Principle 2…Blocks near resources important to crop-eating birds are at higher risk for damage. One should expect higher proportions of damage: 1) in blocks under wires, 2) at edges of blocks, particularly those near non-fruit areas, 3) near night roosting sites, 4) in isolated blocks with little human activity, 5) potentially blocks near dairy farms.

Each farm is unique and should be assessed for risk factors. For example, wooded edges of blocks can provide "staging areas" for crop-eating species like American robins.

Management strategies

Using multiple scare deterrents, deploying them early in the growing season, and moving them frequently improve the likelihood they will be effective in deterring birds.

Some deterrents, like lasers, work in particular situations. For example, lasers deter Canada geese in low-light situations. However, lasers are not likely to deter many of the pest birds seen in crops during the day. Effigies (dead birds hung in the crop) may deter crows.

Bird deterrent sprays that contain methyl anthranilate should be applied following the label as closely as possible to increase the likelihood of effectiveness (**Figure 1**). For example, generally they should be applied with foggers and the product should come into direct contact with birds.

Increasing resources for beneficial predators can aid in vertebrate pest management. For example, providing nest boxes for predatory birds can increase their activity in crop areas. One common predatory bird, the American kestrel, preys on rodents, insects, and small birds. However, habitat must be appropriate to attract predatory birds (**see information below**). These types of biodiversity-friendly pest management strategies may be useful in marketing.

Bird management strategies of the future may include unmanned aerial systems.

Take-home messages

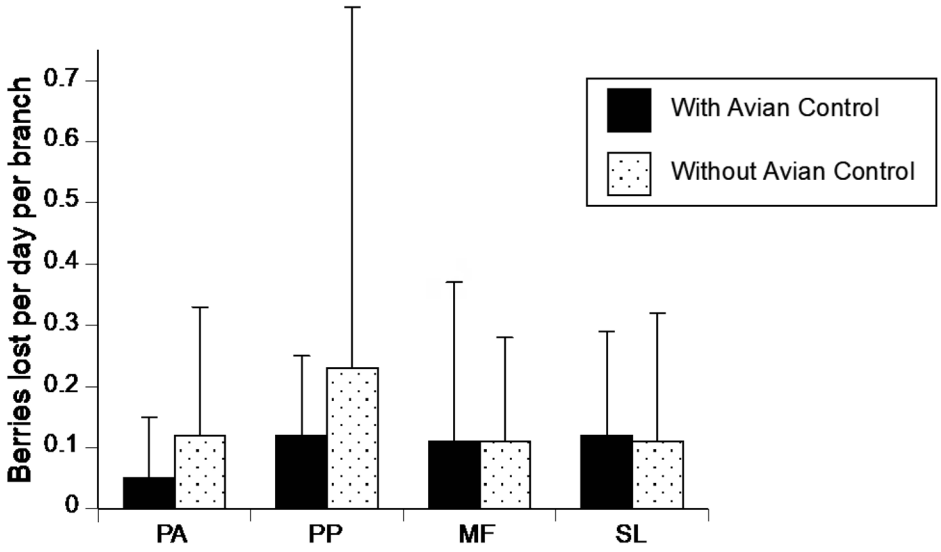
Assess risk
Decrease resources for fruit-eating birds
Match number and intensity of deterrents to risk level
Increase resources for beneficial predators

Catherine Lindell is an Associate Professor in Integrative Biology at Michigan State University with a joint appointment at the Center for Global Change and Earth Observations. She investigates strategies to deter bird pests from cropping systems and is particularly interested in how to make agricultural landscapes attractive to species that prey on vertebrate pests. She is originally from upstate New York. She earned her B.A. from Yale and a Ph.D. from Harvard in Organismic and Evolutionary Biology.

Webpage of interest

Bird management planning is addressed in detail in Tracey et al. (2007), pages 211-218, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/193739/managing_bird_damage-full-version.pdf.

Figure 1.



In 2015 we cooperated with a blueberry grower who sprayed half of 4 fields with Avian Control before harvest and left the other half unsprayed. We sampled approximately 40 canes from each half of the four fields for a total of approximately 320 canes sampled. We counted berries on each cane approximately three weeks before harvest and again 2-3 days before harvest. We did not detect a statistically significant difference in the number of berries lost per day in the sprayed vs. unsprayed halves of the fields.

Installing and Monitoring American Kestrel Nest Boxes

Plans for the Spartan kestrel nest box and mounting tower (designed by Tom Comfort) can be found here: http://www.nestboxbuilder.com/nestbox-article-spartan.html

Additional plans for a simple kestrel nest box can be found here: https://www.peregrinefund.org/docs/pdf/misc/2011-kestrel-nest-box-instructions.pdf

Please consider contributing to the nationwide kestrel nest box monitoring effort by registering your boxes with the American Kestrel Partnership. You can get started here: http://kestrel.peregrinefund.org/begin-obs

Important note:

Kestrels in orchards eat voles and mice, so rodenticides should not be used in orchards when kestrels are present.

Box location

Boxes should be installed away from wooded areas to reduce the risk of occupancy by European Starlings. Open habitat with sparse trees/shrubs is desirable.

Boxes mounted on their own poles/towers can be installed within the orchard itself, either at the end of a row or within a row in an open spot if there is a missing plant.

Boxes should be installed at least one-half mile apart to allow for kestrel territoriality.

Box characteristics
Boxes should be installed 10 – 20 feet from the ground. The box entrance should face the southeast, for studies have shown that kestrel nests are more successful in boxes facing this direction.

Box maintenance
Kestrels do not build nests, so the bottom of nest boxes should be lined with wood shavings or animal bedding.

Boxes that were occupied during the summer should have the wood shavings replaced during the following fall/ winter or early spring in preparation for the next breeding season.

If a European Starling occupies a box, it will add grass and other materials to the box and lay 5 – 7 pale blue eggs. An identified starling nest should be removed from the box, and new wood shaving should be added to the box if needed.

By Megan Shave and Catherine Lindell, Michigan State University. Contact C. Lindell for more information: lindellc@msu.edu

BLUEBERRY PRODUCTION IN FLORIDA – A DIFFERENT WAY OF GROWING

Carla Burkle
Cumberland County Extension, 310 Allen Road Suite 601, Carlisle, PA 17013

Blueberries from Florida are the first to ripen in North America, capturing the lucrative early-season market and affording growers a premium price for their harvest. Capturing this market is made possible by the availability of improved selections called "Southern highbush" blueberries. The profitability of early season blueberries is volatile due to competition from other markets, high production and harvesting costs, and environmental factors. Commercial blueberry producers in Florida cope with this volatility through diversified points of sale and improved production practices. Nevertheless, retaining high profitability is a challenge.

Southern highbush blueberries

Blueberries are one of the few commercially produced fruits that are native to North America. The highbush blueberry, *Vaccinium corymbosum*, is native to northern U.S. states and cultivars of this species are grown in northern states where blueberries are commercially important. The highbush blueberry has a high chill requirement and will not set fruit without a minimum number of days below a certain temperature. Cultivars of this species set fruit in clusters at the end of a cane, making harvesting easier.

Rabbiteye blueberries, *Vaccinium virgatum*, and Darrow's blueberry, *Vaccinium darrowii*, are native to the southeastern U.S. These species have low chill requirements and will set fruit in the milder winters common to the South, but have less desirable horticultural traits for commercial production than highbush blueberries. Fruit from these species matures over a longer period, making it difficult to meet demand during a particular timeframe, and tends to be dispersed in smaller clusters throughout the shrub, making harvest more time-consuming.

Interspecific hybrids of *V. corymbosum, V. virgatum,* and *V. darrowii* were created by the blueberry breeding program at the University of Florida and termed "Southern highbush blueberries". These hybrids combined the fruit set habit of highbush blueberries with the low chill requirements of rabbiteye and Darrow's blueberries to create an early maturing blueberry that could be shipped early in the season. Florida's Southern highbush blueberries are the first available when the season begins, making the crop very profitable from April 1 to May 20. After this date blueberries from Georgia and North Carolina enter the market and lower the profitability.

Diversifying points of sale

Almost all of Florida's blueberry crop is Southern highbush cultivars grown for shipment during the April 1-May 20 early market window. Prices during this market window are volatile and a late frost can ruin a grower's crop. Many growers grow rabbiteye blueberries for sale at roadside stands and U-pick operations to diversify their income streams.

Rabbiteye cultivars mature later in the season and over a longer period, as opposed to Southern highbush cultivars that mature roughly four to six weeks earlier. Rabbiteye blueberry orchards are popular U-pick destinations from mid-May through the summer. Grower costs are generally low once these orchards are established and though the price per pound is lower than Southern highbush blueberries, it's almost all profit.

Carla Burkle is a Horticulture Extension Educator at Penn State University, based in Cumberland County, PA. She advises commercial vegetable growers on diagnosis and management of pest, disease, nutritional, and cultural issues in their operations and conducts training and education for commercial growers throughout the state of Pennsylvania as part of the Statewide Horticulture Team. She also conducts applied research in vegetable entomology and plant pathology, and field trials of new cultivars. She has a B.S. in Plant Science and Doctorate of Plant Medicine, both from the University of Florida. Prior to joining Penn State, Dr. Burkle taught agriculture in rural north Florida.

In addition to U-pick, growers may sell their blueberries at roadside stands, farmers markets, or through co-ops and brokers.

Improved production practices

Planting blueberries in Florida is expensive. Young plants are typically planted in pine bark mixed into sandy soil, with drip tape installed under ground cloth. Soil pH usually has to be lowered to 4.0-5.0 by acidifying irrigation water. Establishing a blueberry orchard costs between $20,000-25,000 per acre, not including the cost of land. Production costs in the first year can be as high as $4000 per acre, not including harvesting costs.

Growers can reduce the amount of pine bark needed by planting in low-lying areas, as these are generally higher in organic matter than higher elevations. Cost savings are offset however by the significant risk of frost in low areas. Growers must balance the potential reward of getting their crop out first by planting early-flowering cultivars with the definite risk of late winter and early spring frosts. Irrigation is commonly used for frost protection in Florida, and can be a significant cost. There is interest in growing evergreen, or non-dormant blueberry varieties further south in Florida where there's less risk of freezes as another way of lowering freeze protection costs.

High tunnels are not widely used in Florida currently due to the added cost of construction, variable performance of different cultivars in the high tunnel environment, and extended harvest seasons that may miss the prime market window. However, some growers are adopting this production practice to lower freeze protection costs and harvest earlier in the season.

Harvesting costs are high since blueberries are harvested almost exclusively by hand. As labor becomes increasingly difficult to secure, some growers are turning to machine harvesting to lower harvest costs later in the season when the fruit is less valuable. The blueberry breeding program at the University of Florida is attempting to identify cultivars that are compatible with machine harvesting, as labor is likely to continue to be a significant issue.

The Florida blueberry industry has a unique opportunity as a result of being virtually the only blueberries available early in the season. Florida blueberry growers must balance the potential gain from premium prices with the losses incurred by high production costs and market volatility.

MULCHES AND AMENDMENTS FOR BLUEBERRY PRODUCTION

Rich Marini and Kathy Demchak
Penn State Univ., 102 Tyson Bldg., University Park, PA 16802

Blueberries normally grow best in acid peat or sandy soils with a high water table. There seem to be several reasons for this, including the plants' adaptation to soils that are non-compacted, relatively moist, and low in pH. The optimum soil pH for blueberry production is 4.5 to 4.8, but satisfactory growth usually occurs over a range of 4.0 to 5.2. Within this pH range, the availability of nutrients is quite different from that of typical agricultural soils. Calcium levels are typically much lower, and certain micronutrients, especially iron, zinc, manganese, and copper, become more available. In fact, blueberries belong to a group of plants known as "calcifuges", meaning "calcium-fleeing". However, many PA blueberry growers have farms with clay or loam soils in valleys with limestone parent material. According to USDA-NASS, between 2002 and 2012, the number of farms growing blueberries in PA more than doubled, from 326 to 799, as did acreage, from 421 to 1033 acres. Much of this growth is occurring in the southeastern part of the state, so many new plantings are in soil that is very different from the acidic soils to which they are suited.

Blueberry has a shallow fibrous root system, with no root hairs unlike other crop plants. Even when soil is maintained at a proper pH, blueberries may not grow well in loam or clay soils common in Pennsylvania, probably because its fibrous roots, most of which are about the thickness of a human hair, can't penetrate compact soils. Adding organic matter, such as sawdust or peat, to such soils usually improves growth by improving soil structure. Another important benefit of organic matter is maintaining soil moisture.. Organic matter also provides plant nutrients and reduces nutrient loss from leaching. Potassium, calcium and magnesium are retained in the soil exchange complex of organic matter, and nitrogen and phosphorus may be converted to organic forms by micro-organisms and released later for plant uptake. Under acid conditions nitrates are converted to ammonium nitrogen by ammonifying organisms in the soil. The ammonium form of nitrogen is more readily utilized by blueberry plants rather than the nitrate form, which is used more readily by most other crop plants. Acid soil also provides a favorable environment for ericoid mycorrhizal fungi associated with blueberry roots and the supply of nitrogen to the plant by the fungus, though an improvement in plant growth from this symbiosis has proven difficult to show in commercial agricultural settings.

Mulching blueberries usually enhances plant growth by reducing weed competition, reducing moisture loss from the soil surface and gradually releasing nutrients. Results from mulching studies with blueberries are inconsistent depending on the mulching materials and the soil type. Griggs and Rollins (1947) found that sawdust gave better yields than clean cultivation or hay mulch, and nitrates were converted to ammonium by microbial activity under sawdust. Shutack et al. (1949), working with Narragansett loam found that plots mulched with sawdust had higher yields than those mulched with hay and hay resulted in higher yields than no-mulch. Taylor (1953) also found that 1" of sawdust mulch increased yields. Blueberry recommendations for Arkansas and Missouri have included incorporation of sphagnum peat in the planting hole (Moore, 1976), but Odneal and Kaps (1990) found that incorporation of fresh or aged pine bark was as effective as sphagnum peat. Krewer et al. (2009) compared pine bark, pine straw and plastic woven ground cover as mulches in a young planting of rabbiteye blueberries in Georgia and found that all three encouraged better growth and cropping than bare ground and pine bark and pine straw were superior to the woven ground cover.

Most previous report did not mention the source of the sawdust (hardwood or softwood). The effects of sawdust incorporation or mulching on soil pH and soil nutrient concentrations have been minimally researched. Research

Kathy Demchak has been at Penn State since 1983, working first in the area of vegetable and tree fruit nutrition and later in berry crops. Recent research projects have included work on blueberry cultivar evaluation, blackberry cultivar evaluation and cold-hardiness, high tunnel production of strawberries, raspberries, and blackberries, and day-neutral strawberry production. She earned a B.S. in Horticulture from Penn State and an M.S. in Horticulture from Virginia Tech. She happily lives in a rural area of Centre County, with husband Jeff, and sons Tim and Jeff

from other countries indicates that sawdust may either raise or lower the soil pH, depending on the tree species from which the sawdust originated (McCool, 1948). Researchers in one study concluded that softwood sawdust tends to lower soil pH more than hardwood sawdust (Shutak and Christopher, 1951), though the differentiation between softwoods and hardwoods may be less important than that of species within each group. Sometimes pH effects on soil were negligible (Tukey and Schoff, 1963), possibly due to the original pH of the soil relative to the pH of the sawdust. What is clearer is that the pH of sawdust as it is leached and decomposes tends to increase, especially for certain species such as oaks (McCool, 1948), perhaps because the inorganic elements in wood are primarily calcium, potassium, and magnesium (Rowell et al., 2012). We are unaware of research that characterizes long-term effects of sawdust application on soil levels of these nutrients and its subsequent effect on plant nutritional status, especially in soils where the native pH already is high. Interestingly, Penn State recommendations discourage the use of sawdust from beech or ash, as these species can raise the soil pH. Work in Georgia stated that "Addition of S was less effective than sawdust in overcoming harmful effects of high soil pH" (Cummings et al., 1981).

Another potential soil amendment that has recently been investigated is waste sheep wool, which contains N, Ca, P, K, Mg, Fe and Mn and has also been reported to slightly lower soil pH (Zheljazkov et al., 2008).

Although blueberries unquestionably benefit from organic matter, the question remains whether hardwood or softwood additions are better, and whether certain other as yet untested organic materials such as waste wool would be suitable as a soil amendment or mulch. Further, few studies have been conducted on limestone soils that are common in the northern mid-Atlantic region.

To answer some of these questions, cell-grown 'Patriot' blueberry plants (Nourse Farms) were planted on May 29, 2015 at the Horticulture Research Farm at Rock Springs, into a bench above the valley floor with a native soil pH of 5.1. Planting holes were amended with 1.5 gallons of sphagnum peat moss, 1.5 gallons of pine (softwood) sawdust, 1.5 gallons of oak (hardwood) sawdust, or 0.22 pounds of washed sheep wool. It should be noted that the sawdust was not decomposed, as only fresh sawdust of known types could be obtained, as is commonly the case for growers as well. On July 13, 2015, 4" of either hardwood or softwood sawdust or 1.76 pounds of washed sheep wool was applied to a 2'-wide strip under the plants.

The pH of both types of fresh sawdust was low, at 4.2 for softwood sawdust, and 4.7 for hardwood sawdust. The main difference was in the carbon to nitrogen ratio (nitrogen tie-up occurs at ratios higher than 30:1), with the softwood and hardwood sawdust having C:N ratios of 187:1 and 422:1 respectively.

Plants were fertilized with ammonium sulfate or urea according to standard recommended rates in 2015, 2016, and 2017. Blossoms were removed in each spring but were counted for an indication of yield potential.

Soil samples were analyzed in 2015 and 2017, and leaf samples were analyzed in 2015, 2016, and 2017. In late summer of 2015, leaf nitrogen levels were within normal ranges as long as peat moss was the material incorporated into the planting hole. Incorporation of softwood sawdust appeared to provide acceptable growth and borderline low leaf N levels, whereas use of hardwood sawdust resulted in nitrogen levels being at extremely deficient levels in the planting year. Plants receiving wool as either a soil amendment or mulch had leaf nitrogen levels in the excessive range.

Overall, during the three seasons of this study, plant growth has been affected by the treatments. Plants receiving peat moss as the soil amendment incorporated at planting were the largest after the first growing season and remain the largest after three seasons. Throughout the study, the smallest plants were those with the incorporated hardwood sawdust soil amendment plus hardwood sawdust mulch and those receiving the wool soil amendment and wool mulch. This was somewhat surprising since during the first season, treatments with wool mulch had the highest concentrations of leaf nitrogen; however, the reduced growth may be explained by leaf manganese levels that were in ranges considered to be excessive by the third year. Plants with hardwood soil amendment and hardwood mulch consistently had the lowest N levels and as expected they were also among the smallest plants.

In both 2016 and 2017 the treatments with peat soil amendment that received either softwood or hardwood mulch had the most blossoms, and the plants with hardwood soil amendment and hardwood mulch had the fewest blossoms.

Most universities currently recommend mixing peat moss or composted sawdust into the planting hole. Our data support this practice, but peat moss is a nonrenewable resource and composted sawdust is difficult to find. Our data show that newly planted blueberry plants grow nearly as large when soil is amended with noncomposted softwood (pine) sawdust as with peat moss; however, number of flower blossoms was significantly higher when peat moss was used as the soil amendment. When growers have a choice of sawdust, softwood (pine) is preferable to hardwood (oak) sawdust as a soil amendment and to a lesser extent as a mulch. Yield data will be collected over the next two years and growth will be tracked to see whether these effects continue.

Thanks to the State Horticultural Association of Pennsylvania for providing funding for this work.

PRUNING: THE ART AND THE SCIENCE - CONCEPTS, PRINCIPLES, AND PRACTICES

Mark Ehlenfeldt, USDA-ARS
Marucci Center for Blueberry & Cranberry Research and Extension
125A Lake Oswego Road, Chatsworth, NJ 08019
mark.ehlenfeldt@ars.usda.gov

The Seven Basic Concepts of Pruning – Why we prune

1. Promoting fruit quality – pruning balances crop load and improves fruit size and quality.
2. Bush rejuvenation – The goal of pruning is to remove canes that are 5 years old or greater and to stimulate the plant to produce new canes. A bush should have a balance of canes from 1 to 5 years old.
3. The need to keep the bush in balance – A bush needs to have a balance of vegetative and fruiting tissue. Too much fruiting wood produces small, poor quality berries.
4. The need to promote vegetative growth – Within the fruiting season, vegetative growth is needed to support fruit development. Beyond the fruiting season, vegetative growth is needed to build root reserves and store energy for the following year.
5. Opening the bush – Opening the center of the bush allows light penetration to nurture new shoot growth, it also promotes better air circulation which reduces fungal disease.
6. Shaping the plant – Things we don't want: excessive low, twiggy growth, interiorly crossing branches, overly lanky drooping growth.
7. Removing the "ugly" – This encompasses many of the concepts above, and becomes almost intuitive after a bit of practice.

An important resource for pruning technique

A Grower's Guide to Pruning Highbush Blueberries (with Dave Brazelton of Fall Creek Farm & Nursery)

https://media.oregonstate.edu/media/t/0_05v1qew6

This video encompasses all of the basic processes of pruning blueberry bushes and is an excellent training and review document!

The Process of Pruning - Oregon style

1. Remove low growth
2. Remove brushy, twiggy, and diseased growth.
   Cut back to new wood.
3. Remove old fruiting wood.
4. Thin fruiting laterals.
   Bottom up or top down (heading)
   A cane will support 4 - 8 laterals
5. Shape the bush.

Dr. Mark Ehlenfeldt is a Research Plant Geneticist with the United States Department of Agriculture - Agricultural Research Service. In his USDA position he is responsible for the breeding and development of new blueberry cultivars for U.S. blueberry producers. He has released 12 blueberry cultivars, including: 'Legacy', 'Hannah's Choice', 'Cara's Choice', 'Pink Lemonade', 'Sweetheart', 'Nocturne', and 'Razz'. His latest work involves northern-adapted rabbiteye hybrids and reflowering blueberry hybrids

The Process of Pruning - New Jersey style
(similar to Oregon, but slightly different)

1. Remove low growth
2. Remove brushy, twiggy, and diseased growth
3. Remove crossing growth
4. Open center of bush (remove 1 of 4, 1 of 6)
5. Little detail pruning is done.
6. Shape the bush.

Remember: A vigorous bush is easier to prune than a weak bush. A weak bush needs to be pruned for the future. Be merciless. Remove fruiting wood, and prune severely to encourage new growth in the next year. Continued weak growth suggests the need for cultural improvement, bush replacement, or both.

STRATEGIES FOR SUCCESSFUL WEED CONTROL IN HIGHBUSH BLUEBERRIES

Thierry E. Besançon and Baylee Carr
PR Marucci Center and Department of Plant Biology, Rutgers University
125a Lake Oswego Rd, Chatsworth, NJ 08019
thierry.besancon@rutgers.edu

Weeds remain a major challenge in highbush blueberry (*Vaccinium corymbosum* L.) production. Like for any other agronomic system, annual grasses and broadleaves account for most of the weed species. However, the lack of annual crop rotation and soil cultivation make blueberry plantations more prone to the development of hard-to-control perennial weeds. Additionally, the number of herbicides labeled on blueberry is limited compared to row crops. Thus, efficient weed management strategies will rely on various control measures that need to be tailored to weed populations specific to your blueberry plantation. This presentation will cover the basics of a successful weed management program from proper weed identification to the selection of appropriate tools to control weeds.

Weed Biology Basics: Weeds can be divided into three groups. Grasses are a single botanical plant family with jointed stems, leaves with parallel veins that are divided into a blade and a sheath that wraps around the stem. Sedges appear like grasses at a glance. Leaves are narrow with parallel veins, but they are not divided into a blade and sheath. Sedges have a distinctly triangular stem. Broadleaf weeds are a large collection of diverse plant families that have wide leaves, showy flowers, and seeds that are divided into two halves. Among these three groups, species can be subdivided based on their seasonality. Annuals are weeds that live less than a year. Summer annuals germinate in the late spring and early summer, flower and set seed in late summer or early fall and die when it gets cool. Winter annuals germinate in the fall or early spring, flower and set seed in late spring, and die when it gets hot. Biennials are weeds that live longer than a year, but less than 2 full years. Perennials are weeds that live longer than 2 years.

Prevention: The first step of any weed management program is to consider the steps that need to be taken to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species. The purchase of weed-free seeds when sodding the row middles, the necessity of cleaning equipment before moving from infested to non-infested fields, the use of weed-free irrigation water, the control of weeds on field borders and ditches, and prohibiting weeds already present from going to seeds are some of the key elements of an effective weed prevention program.

Weed Scouting: Prevention is a necessary step but is not sufficient by itself. Weeds have generally to be targeted at the seedling stage since controlling fully developed weeds can be extremely difficult because of their size that prevent effective herbicide distribution on the plant or because of their ability to regrow following mechanical or chemical control. Scouting for detecting weed seedlings shortly after their emergence is a critical component of any successful weed management program. The goal of weed scouting is to get a representative idea of the weed populations throughout the whole field. For a 100-acre field, make 5-10 stops that are well spread out through the field. At each stop, walk 10 paces (or 30 feet) and record the weed species that are present as well as their lifecycle (summer annual, winter annual, perennial), growth stage or height, and the severity of the infestation based on number of plants (low, medium, high). An efficient scouting program should also provide information on crop phenology as this may ex-

Thierry Besançon
Rutgers: Phillip E. Marucci Center for Blueberry and Cranberry Research. 125a Lake Oswego Rd. Chatsworth, New Jersey 08019
thierry.besancon@rutgers.edu
Ph.D.: North Carolina State University. 2015
From: Epinal, France.
Title: Extension Specialist in Weed Science / Assistant Professor.
Current Research: Weed control in cranberry and blueberry, developing sustainable weed management strategies for specialty crops.
Previous experience includes pest and disease management in stone fruit production, development of IPM threshold models, prediction of fruit shelf-life in cold rooms, weed control through cultural practices, and crop allelopathy in sorghum as well as other row crops.
Interest: Birding, hiking, gardening, photography.

tremely important with regards to chemical weed control. The use of farm maps for weed scouting will provide data that can be used to define the control strategy but also assess its efficiency at controlling weeds over time.

Identification: Accurate weed ID is important for effective management because herbicide recommendations vary according to species, as do some mechanical, cultural, and biological strategies. Some species can look similar to other species from afar, but may have drastically different management requirements. They should be examined closely to determine herbicide programs. Guides such as Weeds of the Northeast (http://www.cornellpress.cornell.edu/book/) or weed identification websites (http://oak.ppws.vt.edu/~flessner/weedguide/) can be helpful to accurately determine weed species and become familiar with their biology and ecology.

Cultural Weed Control: Weed control should be started even before planting blueberries. While total "weed-free" soil is not usually possible, growers should keep clean soil prior to planting by ridding the soil of weeds through a burndown herbicide application, a thick, suppressive cover crop mulch, or mechanical weed control such as tillage and cultivation. Preventing seed production of weeds already growing in the field through frequent soil cultivation will help reducing the soil weed seedbank. Additionally, light cultivation will stimulate the germination of some weed seeds contained in soil and repeated soil work will eliminate recently emerged seedlings.

Complete weed control is critical the first two years following blueberry planting to ensure high survival rates and quick establishment as weed competition can dramatically slow growth of young plants. Frequent hand hoeing or hand pulling of weeds is recommended as mechanical cultivation may damage the root system and slow the growth of newly planted blueberries.

Similar to new plantings, the use of mechanical cultivation equipment in the row of established plantings is seldom recommended due to risk of damaging the shallow roots of the blueberries. Weeds control on the row can be achieved with mulch such as sawdust, wood chips or coarse leaf mulch applied three to four inches thick when the rows are weed free. The use of mulches such as straw is not recommended as these provide a favorable environment for rodents such as field mice and voles that may damage blueberries root and stems. All organic mulches break down over time and tie up important nutrients, especially nitrogen, so the use of mulch may require additional fertilizer. Mulch should be reapplied annually or when needed to maintain weed suppression.

Weed management of the row middles can be done through the seeding of a dense sod that will compete with weeds but will require fifteen to twenty months to establish. During this period, it is critical to control broadleaf weeds growing in the sod. The flowers of dandelion, clover, mustard species and other weeds may coincide with bloom and are preferred by pollinating insects. The same weeds, and others, may also bloom before or after the crop blooms and attract bees into the field when insecticides must be sprayed. Clover can especially be difficult to control, but can be suppressed or controlled in a sod with good management practices that will favor grasses such as appropriate fertilization with nitrogen or mowing height no closer than four inches from the ground.

Chemical Weed Control: Chemical weed control has many advantages, including control and cost efficiency, safety when correctly used, and the elimination of crop and root injury caused by cultivation. However, in order to mini-

Baylee L. Carr
Rutgers: Phillip E. Marucci Center for Blueberry and Cranberry Research. 125a Lake Oswego Rd. Chatsworth, New Jersey 08019
baylee.carr@rutgers.edu
Bachelors: Rutgers University, New Brunswick Campus. 2016
High School Diploma: Delsea Regional High School. 2009
From: Franklinville, New Jersey.
Title: Field Researcher
Current Research: Weed control in cranberry and blueberry, developing sustainable weed management strategies for specialty crops.
Previous experience has included work in the vegetable pathology department on phytophthora in peppers, anthracnose in peppers and tomatoes, root knot nematode in cucumber, downy mildew in basil and cucurbits, and powdery mildew in cucurbits as well as other diseases.
Interest: Improvisational theater, crafting, gardening, and cooking.

mize potential problems with herbicides, some specific considerations should be addressed before using them.

FACTORS AFFECTING THE EFFICIENCY OF WEED CONTROL

- Target – Is herbicide labelled for the targeted weed species?
- Soil properties – Is the selected rate appropriate to soil texture and organic matter content?
- Timing - Is herbicide used at the right time in relation with crop and weed phenology?
- Activation - Has preemergence herbicide been activated with sufficient rainfall?
- Persistence - How is irrigation affecting the persistence of active ingredients?
- Resistance – Has the targeted weed developed resistance to the active ingredient?

Weed Control Challenges: Perennial weed remain difficult to control in blueberry production. Special attention should be given to remove them from the field before planting the blueberries as this is the ideal timing to safely control them with systemic herbicides and avoid damaging newly planted blueberries. Among the most challenging perennial weeds, yellow nutsedge (*Cyperus esculentus* L.) occupies a preeminent position given its specific life cycle. Although the weed can reproduce from seed, where it is established, annual re-infestation is primarily due dormant tubers ("nuts") in the soil. Tubers can re-sprout six to eight times if cultivation kills the shoot. After the plant becomes established, rhizomes begin to grow in late spring, and by early to mid-summer, the rhizomes curve upward and produce additional plants. By August, the weed can sense the approach of fall by the longer nights, and a burst of rhizome growth follows. By early fall, a pronounced swelling can be observed at the tip of each rhizome, which matures into a new dormant tuber. Later in the fall, separation of the tuber from the rhizome will occur following mother plant death. Yellow nutsedge can be controlled by preventing new tuber production. This can be done by persistent control of nutsedge from late summer through early fall. The results of the effort will not be evident after one year. Too many "old" tubers remain dormant in the soil for several years before they sprout, but after several years, success will be evident.

Development of herbicide resistant weeds is an increasing challenge for blueberry production. Herbicide resistant weeds are weeds that have developed genetic resistance to certain herbicide groups, or sites of action. This is mostly due to widespread reliance on a small array of common herbicides. When the same herbicide is applied to an area year after year that contains resistant weeds, the susceptible plants die while the resistant ones survive and spread their populations every year. This is especially concerning in blueberry where effective herbicide options remain limited. We will discuss some of the most concerning herbicide resistant weeds in blueberry production and the strategies that can help to improve their control.

COVER CROPS FOR BLUEBERRIES

Kate Brown, Rutgers Univ.

In New Jersey, the time-honored tradition of clean culture blueberry production employs intense tillage and herbicide application to maintain a weed-free environment. Declining soil health is likely a direct result of this cultural practice in a long-lived perennial crop and has led to difficulty with the establishment of new blueberry plantings. The purpose of this study was to test several cover crop species in the low pH, sandy soils of a typical blueberry farm on the Outer Coastal Plain of New Jersey. In March of 2016, a randomized complete block design was set-up at a blueberry farm in Hammonton, NJ with 11 cover crop and mulch/compost treatments with six replications. Individual plots were 8.5 meters by 11 meters to accommodate approximately 35 blueberry bushes for an eventual study of blueberry establishment. The field utilized for this study had been dedicated to blueberry nursery production from 1975 to 2015.

Baseline soil samples were collected in April of 2016 and succeeding samples have been collected every six months to monitor changes in soil organic matter content. Each cover crop is evaluated after planting to determine plant density. Additionally, total biomass production is measured at termination of the cover crop. Throughout the summer of 2017, soil volumetric water content was measured in each plot. Lastly, the influence of each treatment on weed species density and abundance was assessed in July and August 2017.

Development of a greenhouse bioassay to monitor changes in soil health is underway. Soils collected from each plot in the study are potted and planted with cranberry cuttings (stolons). The bioassay takes place over an 8-week period and root weight of cranberry plants are measured. The use of cranberry cuttings, rather than blueberry, is advantageous because they are more uniform, root quicker, and are readily available all year. Another greenhouse bioassay is being developed to evaluate the potential impact of soil organic matter on soil suppressiveness to *Phytophthora cinnamomi*. In this study, rooted blueberry cuttings are grown in field soils from the cover crop trial and inoculated with *P. cinnamomi*. After a 12-week period, root weight is measured and percent inhibition of root growth is determined.

PESTICIDE CALCULATIONS AND SPRAYER CALCULATIONS FOR HIGH TUNNEL GROWERS

Steve Bogash, Technical Sales Manager, Marrone BioInnovations, Inc.

February 1, 2018

Moving from field applications of insecticides, miticides and fungicides / bactericides to high tunnel requires some adjustment in our thinking as we generally push for higher plant density indoors to take advantage of the higher cost per square foot of production area. Put most simply, we put more plants into a tunnel than we ever would in the same space in the field. This increase in plant mass requires some adjustment in our calculations for materials. As we seldom do anything more than spot spraying of herbicides no adjustments are necessary for those applications. Therefore, this presentation will focus on insect, mite and disease management material applications.

Disclaimer: Every state has their own rules for what can be applied indoors, so consult your state department of agriculture before using the lessons in this article. Pennsylvania growers can use most field labeled materials in their high tunnels. The exception are materials containing chlorothalonil as these are often phytotoxic under plastic per the product labels.

In the field, we generally plant tomatoes on rows 6' apart, in high tunnels tomatoes are often planted 4.5 – 5' apart. This immediately increases plant populations by 18% or more in the same area. In order to account for this shift, simply work backwards from plant population. So an acre of field-grown tomatoes would have 4,840 plants (43,560 / 6' distance between rows = 7,260 row ft, then 7,260 / 1.5' distance between plants = 4,840). So if our tunnel(s) have 900 tomato plants total, we take 900 / 4,840 = 19% of an acre by population. If the pesticide label calls for #2 of a particular material, we multiply #2 x .19 (19%) = #.38, or .38 x 16 (oz/ pound) = 6.08 oz total material for the 900 plants in your tunnels. Field grown bell peppers are typically planted on double diagonal rows doubling the population of tomatoes, so use a population of 9,680 plants for bell peppers and follow the same rules when growing them in a tunnel.

-For lessor amounts of material, convert your final amount to be applied to grams: 6.08 oz x 28g / oz = 170 grams.

-For liquids, take your amount to be applied and convert to cc or ml by multiplying ounces x 30. Example: .8 oz x 30 ml / oz = 24 ml or cc.

The easiest way to calibrate your sprayer for indoor use is to fill it with a known about of clean water, spray until empty, count the plants and see what it would have taken to make the complete application. So using our 900 plants from the earlier calculation, we will fill a backpack sprayer with 1 gallon of clean water. In this example, we get complete coverage of 140 plants. So, 900 / 140 = 6.43 gallons, therefore it will take 6.5 gallons of water to make this application today. If we are using a backpack sprayer, then we will need to split the material to be applied between 2 tanks.

The amount of water changes as the season progresses as plants grow and mature, so you will need to calibrate regularly. Also, very young plants can be easily damaged using the labeled full rate of certain materials, so use the lowest rate on young plants and adjust the rate as the season and pest pressure require. Oils such as neem-based pesticides can be very phytotoxic at higher rates on young plants and under high temperature / sunlight conditions.

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve now works with the product development team at Marrone Bio Innovations, Inc to create, field test, and market new biological plant pest management products. He has continued to do applied research in field and high tunnels on bell peppers, tomatoes, cucumbers and processing tomatoes seeking to improve yields and quality. Proactive pest management using biological control agents is an important factor in all of these trials

Steve has been doing extensive trials in high tunnel and field tomatoes, bell peppers, and cucumbers with a focus on plant nutrition and biological pest management since 2000. Evaluating more than 500 varieties of tomatoes for flavor, appearance, disease resistance and general usability has made Steve very opinionated when it comes to tomato varieties.

One of the hardest working tools for vegetable and small fruit high tunnel growers are our backpack sprayers. Using them to their fullest will undoubtedly make for better produce and greater insect, mite and disease management. Here are some tips for using these workhorses to their fullest:

1. **Have separate sprayers for herbicides.** There is no problem in using the same sprayer for insecticides, miticides, fungicides, bactericides and foliar nutrients, but many herbicides are extremely hard to completely remove from sprayers. In many cases low ppm and even ppb of herbicide residue can do serious harm to sensitive plants like tomatoes. Mark the sprayers well with a weather and solvent resistant marker and remark them as the lettering wears over time. Make sure everyone on your team understands how important keeping these separate is to your success.

2. **Consider powered sprayers.** Hand pumped backpacks are inexpensive and great tools when just doing a tank or two, but they get to be a real workout when the weather is hot and humid and we've got multiple tanks to apply. Rechargeable battery powered backpacks are light and provide even application over many tanks keeping the operator fresh. Check out the specifications of these battery-powered sprayers as they vary widely. Low pressure (below 60 psi) is fine for herbicide applications, but higher pressure, thus finer droplet size makes a huge difference in managing insects, mites and diseases. I've gotten great use out of a Dramm BP-4 sprayer that develops up to 150 psi. Finer droplets at higher pressure can directly translate into better coverage on the lower surfaces of leaves which is where many problems get their start. Gasoline backpacks are great for insect and disease control just make sure to ventilate your greenhouse or tunnel well during and after application to reduce fuel fumes and always use hearing protection with these noisy beasts.

3. **Select your nozzle carefully.** Adjustable cone nozzles come with many sprayers and are great multi-use applicators. However, flat tips are often superior when applying herbicides over large areas or covering lots of leaf area evenly. The dual tips that are shipped with the BP-4 noted above produce an impressive 'tornado' effect that does a great job covering a lot of crop quickly and evenly with good lower leaf deposition.

4. **Clean your sprayer well immediately after use.** This is a big deal and one that often gets lost on a busy farm. Many materials can clog sprayer pumps and screens when left at the end of use. Six oz. of liquid ammonia left in a tank for at least an hour will remove most deposits. Rinse the tank well three times after use, push some clean water though the lines and nozzle(s), clean the nozzle screens, then fill with water and the ammonia and let sit. Drain, then flush with clean water and the sprayer is ready to use or store. There are commercial tank cleaners as well.

5. **Keep the fill screen / strainer basket in place.** Backpack sprayers have many small passages and the nozzle screens where fluid needs to move easily. It is always confusing to me when I see applicators remove the basket strainer to fill the tank. If the material to be applied will go through the basket screen, then it is unlikely to clog things where it counts.

6. **Take the time to calibrate your sprayer(s).** There are lots of great and easy to use instructions on how to calibrate you and your sprayer. In general, you will be filling the sprayer with a known amount of water and seeing how far it goes, then doing the math for a full application. I've done this so many times that I know that I can cover about 500ft2 with a gallon of spray using flat nozzles when applying an herbicide at my walking speed. Everyone carries their sprayer wand a bit differently and walks at different speeds, so it's worth the time to get this right. Here again, a powered sprayer eliminates the variable of the pressure changing during application. Certain materials such as glyphosate (Roundup), foliar nutrients, and insecticidal soaps (M-Pede and others) rates are based on percentage of, or amount of material in solution. This eliminates the calibration step as the operator only needs to watch for good coverage.

7. **Use the right PPE.** Rubber boots, rubber gloves and googles are a must as it is nearly impossible to do a good application without getting some material on you. Read the label(s) carefully and follow the recommendations for using the right protective equipment. When working in tight in a greenhouse or tunnel, a Tyvek suit will keep just applied surfaces from soaking skin. Thin plastic raincoats are excellent for keeping tank solution from splashing out and onto your back.

8. **Winter / off-season care.** As growers, we often tend to think more about repairs and maintenance to tractors and related equipment. Taking the time to go over every backpack in preparation for the next season will make for a smoother start. Most manufacturers have good websites for getting parts. Replacing hand grips, shoulder straps and looking for other wear areas will go a long way to reducing startup frustrations. I've seen the craziest knots in torn shoulder straps which reduces the comfort of use substantially. Gasoline backpacks should have fuel stabilizer added to their tanks per the manufacturer's recommendations.

9. **Be nice to your backpack. Use the right backpack for the job. Have dedicated backpacks for herbicides only. Clean your backpack well between uses and storage, and replace parts as needed.**

LEARNING THE POTENTIAL OF GRAFTED INDETERMINATE TOMATOES IN HIGH TUNNELS

Kaitlin Horst- Re-Divined

The outline below is an overview of what I will be sharing about from our experience with grafting and growing grafted tomatoes in 3-season high tunnels since 2007. Notice: although we are approaching these topics for indeterminate tomatoes, including heirlooms, most of these techniques and results can also apply to determinate plants. We have noticed that determinate tomatoes that are grafted show more of an indeterminate habit when grafted on a vigorous rootstock.

Goals to accomplish by using grafted plants:

1. Harvesting fruit for at least 4 months
2. Utilizing the same soil for tomatoes for more seasons
3. Higher Yields

Learned management techniques to approach carefully with grafted plants:

1. Selection of rootstock and rotation of rootstock species from year to year
2. Application of fertilizer. When and how much?
3. Pruning
4. Spacing

Noticeable results from using grafted plants

1. Ability to handle stress better than non-grafted- significantly larger rootmass
2. Healthier plants even in the presence of air-borne bacteria
3. Increase in yields, (we will look at the numbers from our rootstock trials)
4. Longevity of season
5. Still need to plan to rotate crops or at the very least species of roots.

UPDATE ON COLORED HIGH TUNNEL BELL PEPPERS

Timothy Elkner
Penn State Extension – Lancaster County
1383 Arcadia Rd., Rm. 140, Lancaster, PA 17601
tee2@psu.edu

Introduction - Colored bell peppers are a high-value crop for vegetable growers. Producing these peppers in the field is risky because weather conditions can reduce marketable fruit. In addition, field production delays maturity of the crop. Earlier research showed that colored bell production was a good fit for high tunnel production because it helped overcome these two problems. The best red, yellow and orange varieties were identified in 2012 and recommended to growers. Since that trial was completed new pepper varieties have been introduced and this study was conducted to evaluate these new varieties compared to current standards.

Materials and Methods – Thirty-four bell pepper varieties varieties (named and advanced selections) were evaluated using plasticulture (narrow beds) and drip irrigation in a high tunnel. Mature fruit colors were red, orange and yellow. Plants were seeded on April 6 and transplants were set in the tunnel on May 16. There were three 4-plant replications per variety except for 'Dazzle' which only had one replication of 4 plants. Plants were set in the beds in a double row with an in-row spacing of 1.5 ft. No fertilizer was applied preplant based on soil test results and in season fertility was based on recommendations as found in the Commercial Vegetable Production Guide and adjusted based on tissue test results. Harvest started on August 2 and stopped on October 31. Fruit were graded into #1, #2 and cull and each group was counted and weighed. Pests were managed using biological controls most of the season.

Results and Discussion – Red varieties with the highest yields of #1 fruit by weight were Antebellum, Bocca, Karisma, Mercer, Ninja, Red Knight and Sprinter (Table 1). Varieties with the highest yields of marketable fruit (#1 & #2) were Antebellum, Karisma, Mercer, Ninja, PS 1819, Red Knight and Touchdown. CS 1730 and PS 1819 had the largest average fruit size for #1 fruit; Sprinter had the smallest and at 0.42 lbs. is most likely too small for most markets.

All orange varieties had similar yields of #1 fruit by weight except for Garfield which was lower (Table 2). Garfield had the greatest average fruit size at 0.62 lbs. while all other varieties were 0.50 lbs or lower. Average size for orange bell peppers in previous studies was similar to this season and in general this color tends to have smaller fruit. Varieties with the highest total marketable yield per plant were Delerio and Muscato.

Yellow varieties with the highest yields of #1 fruit by weight and good fruit size were Dazzle, Early Sunsation, and Sirius(Table 3). Catriona had good yields of #1 fruit but small fruit size; Galleon had good fruit size but poor yield. Varieties with the best marketable yields were Catriona, Dazzle, Early Sunsation and Sirius.

I would like to thank the PA Vegetable Marketing & Research Board for funding this trial.

Timothy Elkner is a regional horticulture educator based in Lancaster County, PA. His prime areas of responsibility are commercial vegetable and fruit production. He conducts applied research on vegetables and small fruit with an emphasis of variety evaluations. He has a B.S. degree in Agricultural Sciences from Cook College (Rutgers University) and an M.S. and Ph.D. in Horticulture from Clemson University and Virginia Tech, respectively

Table 1. Number and weight of #1, #2 and cull fruit, total marketable weight and total harvested weight of fruit for 22 varieties of red bell peppers grown in a high tunnel in Lancaster County, PA in 2017. Values are for individual plants.

Variety	Number #1 Fruit	Weight #1 Fruit (lb)	Average Fruit Wt. #1 (lb)	Number #2 Fruit	Weight #2 Fruit (lb)	Total Marketable Weight (lb)	Number Culls	Weight Culls (lb)	Total Harvested Weight (lb)	Source**
Antebellum*	4.83	3.18	0.66	1.42	0.85	4.03	3.08	1.91	5.93	TW
Bocca	4.58	3.01	0.66	0.92	0.58	3.60	1.58	1.00	4.60	SW
Cherokee	3.33	2.30	0.69	2.17	1.43	3.72	1.92	1.24	4.97	SK
CS 1730	2.83	2.20	0.78	1.33	0.87	3.07	1.92	1.04	4.11	CS
Green Flash*	3.67	2.52	0.69	1.75	1.04	3.56	1.92	0.93	4.49	CS
Karisma	4.50	3.18	0.70	1.92	1.21	4.39	1.50	0.93	5.33	SW
Majestic Red	4.25	2.40	0.56	1.83	1.06	2.63	2.67	1.24	4.70	TW
Mariner*	1.83	1.15	0.63	1.58	0.94	2.10	2.75	1.48	3.58	CS
Mercer	5.17	3.23	0.62	2.00	1.25	4.48	1.92	1.06	5.54	SG
Mingun	3.50	2.44	0.70	1.75	1.12	3.56	2.67	1.57	5.13	SW
Ninja*	6.25	3.90	0.60	1.75	1.03	4.93	2.75	1.34	6.27	SK
Pepper #1	3.67	2.49	0.68	1.42	0.84	3.33	1.67	0.96	4.29	CS
Procraft	4.67	2.94	0.63	1.42	0.83	3.78	2.00	1.08	4.86	SW
PS 1819	3.67	2.81	0.77	2.25	1.68	4.49	1.58	1.09	5.51	SW
PS 8302	2.00	1.44	0.72	1.92	1.37	2.81	1.33	0.99	3.80	RP
PS 9325*	4.00	2.73	0.68	0.83	0.54	3.27	2.25	1.40	4.66	RP
Red Knight	6.42	3.65	0.57	2.00	1.08	4.74	2.50	1.23	5.96	SW
Samurai*	5.25	2.92	0.56	1.92	0.98	3.90	1.42	0.70	4.60	SK
Sprinter	6.50	3.01	0.46	1.42	0.69	3.72	1.92	0.75	4.47	SG
SV 3255*	3.83	2.54	0.66	1.50	0.90	3.44	2.33	1.38	4.82	RP
Touchdown	4.08	2.63	0.65	2.25	1.38	4.02	1.33	0.73	4.75	SK
Triology	4.00	2.76	0.69	1.25	0.79	3.54	1.42	0.71	4.25	SW

*X-10 variety

**CS = Clifton Seed; RP = Rupp Seed; SG = Siegers Seed; SK = Sakata Seed; SW = SeedWay; TW = Twilley Seed

Table 2. Number and weight of #1, #2 and cull fruit, total marketable weight and total harvested weight of fruit for 5 varieties of orange bell peppers grown in a high tunnel in Lancaster County, PA in 2017. Values are for individual plants.

Variety	Number #1 Fruit	Weight #1 Fruit (lb)	Average Fruit Wt. #1 (lb)	Number #2 Fruit	Weight #2 Fruit (lb)	Total Marketable Weight (lb)	Number Culls	Weight Culls (lb)	Total Harvested Weight (lb)	Source*
Delerio	8.25	3.83	0.46	1.42	0.58	4.42	2.67	0.84	5.26	SG
Garfield	4.25	2.64	0.62	1.42	0.93	3.57	1.92	1.05	4.62	TW
Milena	7.00	3.35	0.48	1.08	0.49	3.84	2.67	1.13	4.97	SG
Muscato	7.67	3.45	0.45	2.00	0.87	4.32	2.08	0.88	5.20	TW
Orenji	6.83	3.38	0.50	0.75	0.33	3.72	3.58	1.51	5.23	SK

*CS = Clifton Seed; RP = Rupp Seed; SG = Seigers Seed; SK = Sakata Seed; SW = SeedWay; TW = Twilley Seed

Table 3. Number and weight of #1, #2 and cull fruit, total marketable weight and total harvested weight of fruit for 7 varieties of yellow bell peppers grown in a high tunnel in Lancaster County, PA in 2017. Values are for individual plants.

Variety	Number #1 Fruit	Weight #1 Fruit (lb)	Average Fruit Wt. #1 (lb)	Number #2 Fruit	Weight #2 Fruit (lb)	Total Marketable Weight (lb)	Number Culls	Weight Culls (lb)	Total Harvested Weight (lb)	Source**
Abay	5.17	3.09	0.60	1.08	0.68	3.76	0.83	0.47	4.23	SW
Catriona	8.75	4.04	0.46	1.42	0.67	4.72	1.75	0.68	5.39	SG
Dazzle***	6.75	3.79	0.56	1.00	0.50	4.29	2.50	1.41	5.70	SW
Early Sunsation	6.17	3.74	0.61	0.75	0.48	4.22	1.83	1.08	5.30	SG
Flavorburst	6.83	3.03	0.44	1.92	0.81	3.83	3.42	1.05	4.89	SW
Galleon*	2.00	1.36	0.68	1.25	0.72	2.07	2.83	1.31	3.38	CS
Sirius	6.25	4.00	0.64	1.00	0.66	4.65	1.08	0.67	5.32	SG

*X-10 variety

**CS = Clifton Seed; RP = Rupp Seed; SG = Siegers Seed; SK = Sakata Seed; SW = SeedWay; TW = Twilley Seed

***Average of 4 plants

HOOPHOUSE HEIRLOOM TOMATOES

Chris Brittenburg, Who Cooks for You Farm

A street fighters approach to organically growing heirloom/artisan hoophouse tomatoes

General process:

- Rootstock Tomatoes are seeded feb 1 (cert organic estamino) (30% excess)
- scion tomatoes seeded twice. 5 days after root stock seeding and then again another 5 days later
- side grafted
- planted in unheated tunnel april 20th. (dbl row cover no hoops…carefully)
- uncovered and recovered daily.
- tie up following rapid growth (once tied can't cover so wait if you can!)
- put tomato clips on main stem at the base of leaf stem above the fruit cluster to support fruit
- clip and prune every 5-7 days when its warm; Pruning is very important in the beginning up until max harvest time. De-prioritized but still pruned a bit after that.

Fertility:

PREPLANT

- 20-25# revita 5-4-5 per 90' bed
- Mix Epsom salt, azomite, aragonite, potassium, boron pak as needed
- compost 1" annually
- Innoculate soil with SC 27 through drip

POST PLANT – FERTIGATION

-we start fish fertigation right away twice a week

- after 2nd week when there are blossoms we begin to feed potassium too
- Fish quantity is increased with tissue analysis. Start 3 weeks post planting and do an analysis for the next 3-4 weeks. Maybe 1-2 more during the season.
- SPECIAL CONSIDERATION – fish fertigation can plug emitters in drip tape. Set your drip tape on the end in a way to open and flush the lines every 1-2 weeks.

Watering:

- Irrigation needs to be thorough or redo it.
- Drip tape 6" spacing and 2 lines per bed. (Rodents!)
- 3 days a week for 2 hours each time
- longer time intervals into July and August.

Chris Brittenburg grew up in Bethlehem, Pa. He went on to college and then traveled about in the US and elsewhere. Approaching his 30's and needing a profession, he decided farming was the air under his wing. With a few years farming under his belt, he met Aeros at a farming conference, fell head over heels and set up to farm on Aeros' family farm. He manages our on farm systems. He calls himself "the machine". He's the director of actions that organizes all the moving parts in the greenhouse, pack shed, and field. From sowing seeds to harvesting fruits he keeps everything moving synergistically.

- water post harvest! We turn water on when we begin harvesting. There is often rodent damage and it can go missed. If you're fertigating you want to make sure the fertilizer is equally distributed so you have to find the holes in the line.

We turn on irrigation while we're inside harvesting. You can hear it hissing.

Harvest (yields 4500 to 5500# per 30x95 hoophouse)

- Harvest a bit under and put tomatoes on shoulders.
- Harvest directly into 10# tomato boxes to sell or bread flats for farmers markets.
- Harvest 3 times a week from early July until late August.
- Heirlooms harvest with scissors or wire cutters and push off stem top with thumb.
- Clean those cutting utensils after every use…or sometimes.
- Heirloom/hybrid marriage varieties harvest with just hands.

Disease:

We primarily manage for leaf mold. (actinovate, serenade, oxidate)

Bred resistance best option. No leaf mold…

Tunnel to field/field to tunnel innoculation

Cool Storage: Critical for heirloom tomatoes

Buys time to sell (1-2 weeks)

Labor:

Sink

Do everything as quick as possible. Ha! Find employees with appropriate

strengths to manage your tomato houses.

There is a lot of time locked up in these houses.

Special Considerations:

BUMMERS…

- leaves get frozen or burned at 28 degrees: single layer plastic, it's cool and clear
- the day leading up to the cool night. Tomatoes recover from a burn but it sets you back approx 2-3 weeks and even then the tomato plants don't grow so well.
- Don't prune leaders you want. When pruning leave 2 leaders on grafted plants. Start from the top and go down counting 2 strong leaders and a backup leader and continue down pruning everything.

CHALLENGES OF SOILBORNE DISEASE MANAGEMENT IN HIGH TUNNELS

Beth K. Gugino
Department of Plant Pathology, The Pennsylvania State University
204 Buckhout Lab, University Park, PA 16802
bkgugino@psu.edu

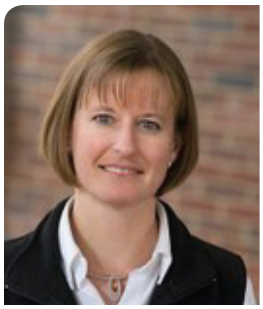
The economic and production constraints associated with high tunnel production can present a unique set of challenges for managing soilborne pathogens but also can justify the use of more expensive management tactics such as grafting. Nevertheless, similar to field production, the majority of available management practices are both proactive and preventative in nature.

Symptoms of timber rot on tomato stems. Sclerotia, the overwintering survival structure, develop as the plant tissue dies (within the circle). When these fall to the soil, they can survive for up to 10 years depending on the soil conditions

True soilborne pathogens are able to survive in the soil over an extended period of time in the absence of a susceptible host/crop due to the production of an overwintering survival structure such as a sclerotia, oospores or chlamydospores. Depending on the host range of the pathogen, this can impact the efficacy of crop rotation as a disease management tool. In high tunnels this effect can be magnified by the frequent decision by growers to monocrop tomatoes over multiple seasons. This leads to the build-up of soilborne pathogen pressure over time with some of the most common ones including timber rot (*Sclerotinia sclerotiorum*), Verticillium wilt (*Verticillium dahliae* and *V. albo-atrum*), Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) and Fusarium crown and root rot (*Fusarium solani* f. sp. *radices-lycopersici*). Pythium and Rhizoctonia root rots can also be a concern.

Timber rot initiates either in a leaf axil, where a flower blossom falls and becomes lodged providing a nutrient source or on damaged stems or petioles. The pathogen does not infect healthy tissue until after it has colonized dead or senescent plant parts first. The lesions are initially water soaked and will gradually enlarge, become bleached then brown in color and cover and girdle the stem. Under high relative humidity, dense white fungal growth can cover the lesions. Large black sclerotia, the overwintering fruiting structure of the pathogen, will develop on the outer surface or in the center of the stems. These structures can survive in the soil up to 10 years depending on the soil condition (temperature, moisture and depth). Timber rot is a cool, moist-weather disease and is especially severe when the temperatures are between 59 and 70˚F under high humidity and/or heavy dews. It has a very wide host range of over 400 different cash crop and weed species.

In high tunnels the primary source of the pathogen is thought to come in from outside the high tunnel. In the spring, the sclerotia in the top 1 or 2 inches of the soil will germinate and produce mushroom type structures called apothecia that will release ascospores (spores) that are carried by the wind. The ascospores are very sticky and if protected, they can survive on the leaf surface for up to 2 weeks. Sclerotia buried deeper in the soil profile will not germinate until tillage or another form of soil disturbance brings them to the soil surface. Secondary spread during the season



Beth K. Gugino is an Associate Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University located at University Park, PA. Her extension and research program focuses on the identification, epidemiology and management of vegetable diseases important to the Pennsylvania and the Northeast region. She received her B.S. in Horticulture and M.S. and Ph.D. in Plant Pathology from The Pennsylvania State University. She was a post-doc at the New York State Agricultural Experiment Station with Cornell University working with diseases of vegetable crops and soil health for four years before returning to Penn State in June 2008.

only occurs when there is direct contact between the diseased and healthy plant tissue.

Verticillium wilt has a very wide host range similar to that of the timber rot pathogen. After a period of time, plants will begin to exhibit symptoms of wilting across a portion of or the entire plant. Partially wilted plants might recover at night until the fungus has colonized more of the vascular tissue within the plant stem. Vascular discoloration tends to extend no more than 10 to 12 inches above the soil line. This occurs typically with the onset of fruiting. The lower leaves may develop V-shaped lesions from the leaf margin. Affected fruits remain small and can develop yellow shoulders. Within the dying plant tissue, very small microsclerotia, similar to poppy seeds, development and either drop to the soil or are incorporated with the crop residue. The microsclerotia remain dormant until triggered to germinate by plant root exudates (sap) of their hosts like tomato or a nonhost such as corn. Verticillium wilt is a cool weather disease and is favored by daytime temperatures between 68 and 75°F. Although multiple plants may be observed dying over a period of time, it is not the result of plant to plant spread.

In contrast to the other two diseases, the pathogen that causes **Fusarium wilt** on tomato has a very narrow host range so this pathogen only affects tomato. Symptoms first appear when the plants begin to fruit. The lower leaves start to turn yellow and may affect only one side or branch of the plant. As the yellowing gradually affects most of the foliage and the plant wilts and dies. The vascular system also becomes dark and discolored as the fungus grows throughout the plant tissue. This discoloration is not limited to the base of the plant as observed for Verticillium wilt. The fungus can survive in the soil as chlamydospores. The disease is favored by warmer temperatures (optimum 80°F), dry weather, acidic soils and the presence of root-knot nematodes. There are three races (strains) of the pathogen. Host resistance is most common for races 1 and 2.

Fusarium crown and root rot is another Fusarium disease of tomato caused by *Fusarium solani* f. sp. *radices-lycopersici*. Symptoms can be similar to those of Fusarium wilt however, similar to Verticillium, the vascular discoloration does not extend more that 6 to 8 inches from ground level however, it is not considered a vascular wilt pathogen. Disease development is favored by cooler temperatures from 68 to 72°F and it has a wider host range including beans, beets, cucumber, barley, onion and asparagus.

Preventative management practices:

- **Clean pathogen-free seed and transplants** and select cultivars resistant to Verticillium and Fusarium wilt. There are recommended high tunnel **cultivars with resistance** to both, including BHN589, Red Mountain, Scarlet Red, etc. Resistance is available for race 1 of Verticillium and to races 1 and 2 of Fusarium wilt however, damage from nematodes can cause a loss of resistance. The majority of tomato cultivars with resistance to Fusarium crown and root rot are indeterminate.
- **Manage soil moisture** and minimize moisture between the soil and lower plant canopy using mulches and suckering lower tomato branches.
- **Sanitation** of tools and equipment when moving between fields and high tunnels. Removal of dead and dying tissue that can be a food source for pathogens especially timber rot. Remove all crop residues at the end of the season.
- **Weed management** in and around the high tunnel is important for reducing potential timber rot inoculum sources. Canada thistle, lambsquarters, mustard, nightshade, pigweed, ragweed, velvet leaf and vetch are all considered hosts.
- **Scout** the high tunnel frequently for pests and diseases as well as for other potential issues.
- Implement **crop rotation** between crop families. Consider diversifying your rotation with parthenocarpic cucumbers, greens or day neutral strawberries.
- **Improve soil health** through use of organic amendments however, conduct frequent soil fertility tests to avoid applying an overabundance of nutrients.

After symptoms are observed:

- Once symptoms are observed, **accurate disease diagnosis** is essential to inform future management decisions such as cultivar or root stock selection. Soilborne wilt type pathogens, including nematodes, can cause very similar symptoms as a result of disrupting the root system and/or colonizing the vascular tissue.
- Carefully and completely **rogue out symptomatic plants** to prevent the development overwintering survival structures. These are often formed in dead and dying tissue; do not wait to remove these plants.
- There **are very few fungicides** that can be applied for the management of soilborne high tunnel diseases. For timber rot, considering applying Contans WG a biological fungicides that colonizes the sclerotia facilitating their degradation. Check the label for application instructions.
- Consider investing in **grafted plants** to improve disease resistance and overall plant vigor. An accurate diagnosis is important for selecting a suitable rootstock.
- Under high disease pressure conditions consider moving to an above the ground **bag or pot culture system** to avoid growing directly in the infested soil.

Future management options to consider:

- **Anaerobic soil disinfestation** is the process of disinfesting the soil by creating anaerobic soil conditions through the incorporation of easily decomposable soil amendments (optimal C:N = 30:1) which is then covered with plastic mulch and irrigated to saturation. The process lasts two to six weeks and results in the accumulation of toxic/suppressive products such as organic acids and volatile organic compounds), biocontrol activity by anaerobic microbes, low pH, low oxygen, and generation of iron and manganese ions; all of which reduce the pathogen populations.
- **Soil steaming** is the process of tarping and using steam heat to pasteurize the soil thereby reducing the populations of plant pathogens, weed seeds, etc. The entire soil mass should reach temperatures between 160 to 180°F for 30 minutes to kill plant pathogens and most weed seeds. The process can result in the accumulation of ammonium nitrogen and toxic forms of manganese so wait several weeks before planting to allow dissipation or conversion to ammonium. Aerated steam at 140 to 160°F can also be used and reduces some of the negative effects associated with higher temperatures.

HIGH TUNNEL ECONOMICS

Art King, Harvest Valley Farms

High Tunnels have become very popular in the last 20 years. We started out with 3 16x96 tunnels modeled after the ones that Penn State did their initial research on, with roll up sides and removable ends. We evolved into larger houses going from a 20x96 to a 30x96. In between we put up a 28x200 Haygrove as well.

All of our future plans involve 30x96 tunnels because that size seems to work best. They will have large roll up doors on both ends, fixed sides, and automatic vents at the top of either end for cooling. Currently we heat two 30x96 houses with a large wood boiler. The heat is only necessary at night. Nighttime temperatures are kept between 40 and 50 degrees. This extends our season by two months in the spring and in the fall. Both have 5 - 48" wide raised beds.

Regardless of what your market is, it is important to get the earliest crops you can, most importantly to extent your income window, but also to get your customers to shop at your farm. But you need to know what to grow and what crops make you the most money. And even that information needs to be continually adjusted. Trends change, populations change, and your growing needs to change with your customers. With all this in mind, it's not just the numbers that are important, it's many other things like: demand, your work force, availability of water, refrigeration, and marketing expertise.

First I looked at growing in a 16x96 high tunnel. These are single layer, roll up sides, and we lay 4 rows of black plastic by hand in early spring.

Net Income

	Income	Expenses	Profit	Profit/SF
Onions	$2,304.00	$782.50	$1,521.50	$1.01
Lettuce	$2,268.00	$572.50	$1,695.50	$1.10
Kale	$3,024.00	$674.50	$2,349.50	$1.53
Bell Peppers	$2,592.00	$808.50	$1,783.50	$1.16
tomatoes	$4,992.00	$855.70	$4,136.30	$2.69

Art King operates Harvest Valley Farms with his son David and his brother Larry in Valencia, PA, just north of Pittsburgh. Their marketing is just as diversified as their product list. Over 58 varieties of small fruits and vegetables are grown on 165 acres. They have a 493 member CSA, sell at 3 farmers markets, Paragon, a large Farm Market & Bakery in Gibsonia, and host pick-your-own pumpkin activities in October.
Art holds a BA Degree in Nature Conservation from California University, Calif., PA and an associate degree in Business Management from Butler Community College. He is Past President of the Pennsylvania Vegetable Growers Association, serves on the PA Simply Sweet Onion Committee, a member of Royal Grange and PASA.

Next I looked at our 30x96 high tunnels with double layer plastic, and raised beds. I calculated each of the 5 beds as 20% of the high tunnel area. The main thing to keep in mind with double layer plastic and a larger tunnel is that you will stay about 6 degrees warmer at night in the double layer tunnel, 30x96 compared to the single layer tunnel 16x96.

Net Income	**30x96**	**w/ Raised Beds**		
	Income	**Expenses**	**Profit**	**Profit/SF**
Spring Mix	$1,890.00	$402.50	$1,487.50	$2.58
Carrots	$1,328.00	$415.63	$912.37	$1.58
Beets	$1,327.00	$389.75	$937.25	$1.63
Arugula	$1,260.00	$383.75	$876.25	$1.52
Radishes	$960.00	$349.90	$611.00	$1.06
Basil	$1,656.00	$563.00	$1,093.00	$1.90

The best thing about having different growing methods is that you can diversify you crops. In this session I will show how I arrived and these numbers and will have hand outs for you to take home and plug in your own numbers so you can see which crops you are growing are making you the most money.

WEED CONTROL AND THE TRANSITION TO NO-TILL

H Grant Troop
Certified Professional Agronomist/Certified Crop Advisor
Regional Sales Agronomist, AgXplore International
Owner/Operator, Troop Farms and Troop Consulting Services

Weed control in sweet corn has always been a challenge. Many growers struggle with how to have a "clean" corn patch. Weeds compete for sunlight, moisture and plant nutrients and they hinder harvest. Successful sweet corn production includes a well-executed weed control plan. Set your sights on giving your sweet corn the competitive advantage in the field.

Organic and conventional growers have many tools at their disposal and we are not saying just pass out the hoes. Organic growers have traditionally relied on tillage including cultivation to keep weeds at bay. With the current emphasis on soil quality, tillage is being reduced on many farm operations in an effort to improve soil health. No-till sweet corn production requires an elevated level of management for success. Transition to no-till sweet corn production requires attention to details that are somewhat skimmed over in tillage systems. We will consider the challenges of transitioning to the no-till production and provide science based, field-tested and farmer proved practices to overcome those challenges.

In tillage systems, "artificial" soil pore space is created by the soil disturbance action of primary tillage such as plowing, chiseling and disking and by secondary or finish tillage such as disking, vertical tillage and field harrowing or cultivation. Soil suffers loss of carbon, structure degradation, erosion susceptibility and a microbial population dominated by bacteria. To maintain adequate pore space, tillage is required every year, thus the soil's addiction to tillage for successful conventional annual crop production.

In the transition phase to no-till, tillage is eliminated and for the first two to three years the soil will become more dense and water tension increases. As the soil becomes more dense, water is held more tightly. During the first two to three years of no-till, a crop can be more susceptible to drought because the soil holds moisture tighter. To overcome this challenge, it is important to use cover crops to generate root zone pore space. The second part of the cover crop equation is to include a winter cereal grain or other suitable crop to produce adequate lignified straw or residue to keep the soil covered during the growing season. If the cover crop consists of the wrong species or the winter cereal grain type component is terminated before the straw lignifies near the boot stage, the ground will be bare when the mulch is needed to conserve water. "Natural" pore space begins to return to the soil as it initializes the process of regenerating native soil structure late in year three on average. The process of soil structure formation will continue to develop unless the soil is disturbed. This is why rotational tillage makes successful no-till difficult. Late year three is when we start to get the soil back to the natural state.

The next challenge in the transition to no-till sweet corn production is planter set-up. In loose worked soil most any planter that will deliver a seed to the proper depth and spacing between kernels will do. In no-till the soil is firm and the seed furrow does not automatically fall closed. The necessary transition planter components include row cleaners, 13-wave no-till coulters, a pop-up and row fertilizer delivery system, single or double disc seed furrow openers and a positive seed furrow closing system, such as Dawn Curvetine closing wheels. The row cleaner action helps with consistent seeding depth, warming of the soil in the row and provides some loose soil to aid row closing at the

H. Grant Troop is a regional sales agronomist with AgXplore Interational, owner and operator of Troop Farms and Troop Consulting Services and a certified professional agronomist and certified crop advisor. He earned his Bachelors in Agronomy at Penn State University and a masters in Biblical Studies from Moody Graduate School. He previously was a staff agronomist for Little Britian Ag Supply in Quarryville PA and a regional no-till agronomist Penn State Extension Educator for the "Park the Plow" program. He is a member of the PVGA, PA Corn Growers and National Corn Growers, Mid Atlantic Soybean & American Soybean Associations and PA Forage & Grassland & American Forage & Grassland Councils. Grant recently commented that, "As we look at the agricultural and environmental issues facing the Mid-Atlantic and Northeast Region, I am convinced that no-till farming, in conjunction with cover cropping and residue management, is the most cost effective fast track route to accomplish the goal of enhanced agricultural land stewardship while increasing farm productivity."

other end of the planter. The 13-wave no-till coulter is the correct transition coulter to provide additional furrow area loose soil and to prevent seed furrow sidewall compaction that is so common when using the wrong coulter. Check the seed furrow openers and replace if worn to replacement specifications. Use a positive closing system that interlocks the seed furrow sidewalls to eliminate sidewall compaction and prevent seed furrow slot opening after planting. Make sure the planter is level front to back and correctly adjust planting unit and closing wheel down pressure.

Fertilizer attachments were mentioned as essential parts of a transition to no-till planter. When tillage is done plant nutrients are oxidized to plant available forms (positive effect) and carbon is lost (negative effect). In no-till sweet corn production, the cycling of nutrients to plant available form is slow until the soil is warm. This is of particular significance in early season plantings. To overcome the delay in the conversion of plant nutrients to plant available forms in the no-till system, plant nutrients are applied as in furrow pop-up fertilizer and row applied fertilizers. Do not exceed N+K2O limits for in furrow and row fertilizer application and use starter safe fertilizer ingredients to avoid salt injury. The in furrow plant nutrient application provides vital nutrients and provides a method to include organic acids, sea plant extracts and microbes including mycorrhizae with products like NutriPak and ValuPak. The strategy is to accelerate plant growth several leaf stages ahead of where you would be without their use. Early to market has a premium. The row fertilizer in a 2x2, 2x0 or surface dribble should supply a major portion of the sweet corn nutrient needs. This strategic plant nutrient placement will greatly reduce the amount of nutrient that is tied up by plant residue in the no-till transition phase, which would happen if broadcast applied.

Now that we have an excellent chance to get the crop established, weed control is of paramount concern. Many growers struggle with weed control. Look at several key factors as you plan a weed control system. You must consider how a stale seedbed will effect season long weed control. If a non-selective herbicide is used to control existing vegetation prior to planting, how weedy will the successive planting areas become before planting. Include pre-emergence herbicides to maintain a fresh or weed free seedbed. Select herbicides that provide good to excellent weed control ratings for the weed population in the field. Remember, weeds may emerge over a longer period in the transition to no-till phase than continuous no-till because the weed seed bank was distributed in the tilled layer. Seeds incorporated into the soil are safe and can emerge from varying depths. Weed seeds deposited on the soil surface in continuous no-till fields are at extreme risk to destruction by weather, insects including ants and ground beetles, earthworms, spiders, bacteria and fungi. Plus, seeds will be at the same depth (surface) in no-till and will have a tendency to sprout and grow at the same time. This is a significant weed control advantage.

The next major weed control issue is the length of residue of the herbicide. Herbicides are classified as short, medium and long residual herbicides. For sweet corn we are usually interested in short and medium residual herbicides for two reasons. First, medium and long residual herbicides will carry over and will alter crop rotation selection. Second, medium and long residual herbicides impact the biomass accumulation of the summer or fall cover crop. For these reasons, choose short residual herbicides, carefully selected medium residual herbicides and, if needed for adequate weed control, low rates of long residue herbicides in an overlapping application system. Short residual sweet corn herbicides include 2,4-D, Armezon or Impact (fresh market), Basagran, Clarity, Option, Sharpen and Verdict (processing). Medium residual sweet corn herbicides include metolachlor (Dual II), dimethenamid-P (Outlook), Permit and Accent Q. The major long residual sweet corn herbicide to use at reduced rates is atrazine. Combination herbicides like Acuron or Acuron Flexi and Bicep Lite II Magnum at full or reduced rates are crop safe and provide tremendous weed control. For further information, go to Agrian.com, click on label lookup and select sweet corn as the crop to see the large number of registered herbicides. For herbicides labeled for specific weeds, enter the weed species you need to control into the appropriate search query. If you are not concerned about crop rotation and cover cropping, the sweet corn herbicide list is very long.

Here is the plan that is highly successful in no-till sweet corn. Be sure perennial weeds are controlled before planting the field to no-till sweet corn. Burn down the cover crop and winter annuals two to three weeks prior to planting or after planting but prior to sweet corn emergence. Remember, a cover crop grown to the proper growth stage is essential for water management in the transition phase to no-till. In tillage systems, tillage is used to attain a weed

free field at planting. In no-till we attain a weed free field with a burndown spray application. Common burndown products contain glyphosate, paraquat or other non-selective herbicide. There are now organic burndown products that have some effect and some growers prefer to roll and crimp their cover crop (winter cereal rye) to terminate it. A weed free field at planting is essential.

A highly recommended practice is to include pre-emergence herbicides with the burndown application to prevent successful weed seed germination before and soon after planting. Products like Verdict or Verdict plus Dual II or Outlook, will control weed emergence until a post plant or post emergence herbicide spray application is made. It is recommended to apply 50-60% of a residual pre-emergence weed control program with the burndown application and overlap 40-50% of the residual pre-emergence weed control program with the post plant (pre-emergence) or post emergence weed control program. Be sure to use the proper spray adjuvants to maximize the performance of the chosen tank partners Many traditional field corn herbicides are registered for use on sweet corn and an ever growing list of organic certified sweet corn herbicides are available.

Transitioning to no-till will have positive outcomes. Those positive outcomes include healthier soil, more efficient water and plant nutrient uptake, less soil erosion, a soil dominated by mycorrhizae, quicker field operations, a reduced weed seed bank, more marketable sweet corn ears and "Farming for Economic Success" smiles.

MANAGING SWEET CORN INSECTS AND RESISTANCE PROBLEMS WITH TODAY'S OPTIONS

Galen P. Dively
Department of Entomology, University of Maryland, College Park, MD 20740
galen@umd.edu

Corn earworm is the primary ear invader of sweet corn, followed by European corn borer, fall armyworm, and sap beetles. Infestation levels in mid-Atlantic region vary with the year, time of season, and farm location. Earworm population pressure is generally higher on farms where this insect successfully overwinters. Maryland has historically represented the northern range of overwintering; however, warming trends have enabled the corn earworm to expand its northern range and buildup populations earlier in the growing season. Earworm infestations also result from migrant moths carried northward on storm fronts into the region during mid to late summer. Fall armyworms overwinter in Florida and the Gulf Coast, and moths migrate into the mid-Atlantic region, usually in early July. The northward influxes of earworm and armyworm moths each year depend on weather conditions and their population size in southern source regions. Corn borer pressure varies depending on the number of generations, and more recent infestations have been significantly lower due to regional population suppression in areas of high Bt field corn adoption. Sweet corn producers rely on timely pest monitoring and insecticide sprays to control these ear-invading insects. However, insecticide control programs are costly, potentially pose exposure risks to the applicator and farm workers, and require considerable time and management to successfully implement.

The cheaper pyrethroid (Group 3A) products have been the popular choice but their control efficacy has declined in certain areas due to resistance in corn earworm populations. Resistance monitoring has been conducted over the last 15 years to track the efficacy of pyrethroids against this insect. When first introduced, pyrethroids provided 95 to 98% control of corn earworm, but currently control efficacy has declined to around 50% due to resistance development. The reality is that pyrethroids no longer provide enough ear protection on many farms, so it is becoming increasingly necessary to switch or rotate to more expensive and newer classes of insecticides. Spray mixtures of Lannate® (Group 1A) plus a pyrethroid are often used to circumvent the resistance problem and improve control of fall armyworms, cutworms, and sap beetles. Rotations and mixtures with different active ingredients, such as Coragen (Group 28), Radiant (Group 5), Entrust and Blackhawk (Group 5), as well as premix products (i.e. Besiege (Group 3A + 28) are also increasingly used and can provide good control. For all insecticide products, timing the first spray at early silking, applying subsequent sprays on a schedule based on moth activity, and achieving adequate spray coverage of the ear zone are prerequisites for effective insect control. Most corn earworm eggs are laid directly on the silks; once larvae hatch, they quickly move down the silk channel and begin feeding on the ear tip, where they are protected from insecticidal sprays. Thus, it is absolutely necessary to target larvae before they enter the ear by treating silk tissue when moth pressure is high. Timing sprays for corn borers and fall armyworms is less critical because their eggs are laid on corn leaves, thus the period of larval exposure to sprays is much wider. Still, effective control depends on getting enough insecticide to the target larvae at the right time, with the proper spray coverage, and without interference from weather events.

The problems and challenges with foliar insecticide applications can essentially be eliminated with Bt sweet corn, which expresses insect-active toxins from the bacterium, *Bacillus thuringiensis* (Bt) in tissues of the entire plant. This technology has revolutionized the way many corn insect pests are managed, particularly European corn borer, which is 100% controlled by Bt sweet corn. However, the expressed toxins alone do not always provide 100% control of

Galen Dively is a native of Blair County, Pennsylvania where he grew up on a dairy farm. He received his B.S. degree (1966) in biology at Juniata College and M.S. (1968) and Ph.D degrees (1974) in entomology from Rutgers University. As Professor and Extension Specialist in Entomology at the University of Maryland since 1972, he has developed many extension programs to assist growers and private consultants in the adoption of pest management practices. After retiring in 2006, he continues to work on research projects focusing on the risk assessment of pesticides on honey bee colony health; efficacy evaluation of new transgenic corn events; field evaluation of new insecticide formulations and active ingredients, with emphasis on organic products; and studies addressing information gaps in the biology and management of emerging pest species."

corn earworm or fall armyworm, and thus supplemental insecticide sprays are often needed to ensure quality ears, especially during high moth activity. There are three types of Bt sweet corn commercially available: Attribute® hybrids (expressing Cry1Ab toxin), Attribute® II hybrids (expressing Cry1Ab and Vip3A), both from Syngenta Seeds, and Performance Series™ hybrids (expressing the Cry1A.105 and Cry2Ab2 toxins) from Seminis Seeds.

Attribute® hybrids have been commercially available since 1996, and acreage has increased significantly with the introduction of fresh market hybrids (i.e. BSS0977, BC0805, WSS0987, GSS0966) and availability of 25K seed units for smaller producers. However, efficacy of these Cry1Ab expressing hybrids has been variable for controlling corn earworm since 2008. Research findings from 22 years of monitoring changes in field efficacy in 89 untreated Attribute® sweet corn plots in Maryland provide strong evidence of resistance development in corn earworm populations to the Cry1Ab toxin. When first introduced, expression of Cry1Ab toxin provided greater than 95% control of all worms, with very minor injury to a few kernels at the ear tip and only early instar larvae if present. The ear protection allowed producers to eliminate pre-silk treatments and reduce insecticide applications during silking by 70 to 90%. However, ear damage and larval survival have progressively increased since 2000. The percentage of Attribute® ears damaged increased from less than 10% in 1996 to an average of 79%, based on 18 trials of untreated plots conducted in 2017 (Table 1). This reduction in control efficacy is unrelated to corn earworm pressure, because moth activity has actually declined over the past decade. Many sweet corn producers have stopped growing Attribute® hybrids or are applying insecticide sprays to compensate for the reduced efficacy.

The Performance Series™ pyramided Bt sweet corn expresses three insecticidal toxins: Cry1A.105 and Cry2Ab2 to control worms, and Cry3Bb1 to control rootworms, as well as herbicide tolerant traits. Common hybrids are Temptation II, Obsession II, Passion II, and SV9010SA. Field trials of Obsession II compared to nonBt Obsession I were conducted in Maryland from 2010 to 2017, alongside Attribute® sweet corn at the same locations. When this Bt sweet corn was first evaluated, control efficacy was similar to the level of ear protection by Attribute® hybrids in the late 90's, providing 100% control of fall armyworms and more than 95% control of corn earworms, with very few surviving larvae and only minor injury on the ear tip. However, control efficacy of earworms rapidly declined during the last four years, showing average unacceptable levels of 74% damaged ears in six late plantings in 2017 (Table 1).

Attribute® II sweet corn expresses a new Bt gene combination to broaden the spectrum of activity and reduce resistance development. Hybrids available are Remedy, Aspire, Milky Way and Protector. Introduced commercially in 2013, this sweet corn expresses a novel vegetative insecticidal toxin, Vip3A, from *B. thuringiensis*, pyramided with the Cry1Ab toxin, along with herbicide tolerant traits. The Vip3A toxin is highly effective against a range of important pests including black cutworm, fall armyworm, corn earworm, and western bean cutworm. Of 22 field trials in 2017 comparing Attribute® II hybrids with non-Bt hybrids in seven states, less than 1% of the ears were damaged, indicating near 100% control efficacy of all ear-invading worms (Table 1). In comparison, the percentage of ears damaged by older larvae in non-Bt sweet corn, planted side-by-side without insecticide protection, averaged 90%. The expressed toxins in Attribute II have no effect on sap beetles; however, the absence of worm damage that attracts beetles significantly reduces the infestation risk of this pest.

Current field performance of Bt sweet corn is summarized as follows. First, all Bt sweet hybrids provide excellent control of corn borers, eliminating all whorl, tassel and silk sprays directed solely for this pest. Furthermore, there is no evidence of any change in corn borer susceptibility to the Cry or Vip toxins. Secondly, the herbicide tolerance traits in these hybrids offer a weed control advantage over non-Bt hybrids. Attribute® sweet corn still provides good control of fall armyworm during pre-silk growth stages but only moderate ear protection; no effective control of western bean cutworm; and variable but generally poor to fair control of corn earworm. Performance Series™ sweet corn provides very good control of fall armyworm during the vegetative and ear development stages but no effective control of western bean cutworm and only poor to fair control of corn earworm. Timing of supplemental sprays in Attribute® and Performance Series™ sweet corn is less critical and wider spray intervals are generally allowed compared to non-Bt sweet corn under the same insect pressure. In both types, fresh silk tissue is consistently more toxic to newly hatched larvae, causing intoxication and delayed growth; so those larvae that survive are exposed longer before entering the ear. Pyrethroids and other insecticides may actually work better because larvae are weakened by

the Bt intoxication. The first spray can be applied at full silk, usually three or four days later than the first application in non-Bt sweet corn. A second spray 3 to 4 days later may be necessary if heavy moth activity continues, and sometimes three applications are needed. Attribute® II sweet corn provides excellent control of all foliage feeding and ear invading worms, thus no insecticidal sprays are required, except for secondary pests such as sap beetles, rootworm adults and Japanese beetles.

Field-evolved resistance and associated reduction in control efficacy reported here confirm findings from studies in the South showing evidence of developing resistance to Cry toxins in Bt field corn and cotton.

However, corn earworm resistance may be localized in the mid-Atlantic region because Attribute® and Performance Series™ hybrids may still provide fair to good control of corn earworm in some areas, depending on where the migrant moths originated from southern sources. Clearly, the high adoption rate of Bt field corn and cotton, with the Cry1Ab toxin being used since 1996, has contributed to the selection pressure on earworm populations. Additionally, moderate dose expression of Cry1Ab and related Cry1Ac toxins in these crops, decreasing refuge compliance, and potential cross resistance between Cry toxins, altogether have contributed significantly to the evolution of resistance. Unfortunately, corn earworm resistance to the Cry toxins is likely to increase, and spread, with the shift to 'refuge in bag' field corn hybrids that contain only 5% non-Bt seeds, and reduced refuge size (from 50% to 20%) in the South where Bt cotton is grown. Due to northward influxes of potentially resistant moths from southern source regions, the risk of further evolution of resistance in the entire Northeast will likely increase and may compromise the efficacy and durability of the Bt sweet corn technology, particular at risk is the Vip trait.

Table 1. Summary of insect control efficacy of different Bt hybrids compared to non-expressing isolines. Data compiled from individual field trials of untreated plots conducted at 15 locations across seven states (NC, VA, WVA, MD, DE, NJ, and NY) in 2017.

Hybrid[a]	Bt traits expressed	Number of trials	% of clean ears	% of ears damaged by corn earworm	% of ears damaged by corn borer	% of ears damaged by fall armyworm
Remedy	Cry1Ab+Vip3A	17	98.7	0.6	0.0	0.1
Milky Way	Cry1Ab+Vip3A	6	96.8	0.2	0.0	0.0
Obsession II	Cry1A.105+Cry2Ab2	7	25.7	73.8	0.0	0.0
BC0805	Cry1Ab	18	23.8	79.0	0.1	1.9
Obsession I	Non-Bt isoline	6	4.3	95.7	0.0	0.3
Providence	Non-Bt isoline	18	12.6	84.4	3.6	6.1

[a] Trials of Milky Way, Obsession II, and Obsession I were conducted only in Maryland.

BIRD DAMAGE IN SWEET CORN – RISK FACTORS AND MANAGEMENT STRATEGIES

Catherine Lindell
Michigan State University Department of Integrative Biology and Center for Global Change and Earth Observations, 1405 S. Harrison Rd., East Lansing, Michigan 48823, lindellc@msu.edu

Risk factors for crop damage by birds

General Principle 1…When there is less fruit or vegetables in a given area, there will be a higher proportion of damage to the crop that is available. One should expect higher proportions of damage in: 1) low-yield years (see **Figure 1**), 2) early-ripening varieties, 3) small blocks.

General Principle 2…Blocks near resources important to crop-eating birds are at higher risk for damage. One should expect higher proportions of damage: 1) in blocks under wires, 2) at edges of blocks, particularly those near non-crop areas (see **Figure 1**), 3) near night roosting sites, 4) in isolated blocks with little human activity, 5) potentially blocks near dairy farms.

Each farm is unique and should be assessed for risk factors. For example, wooded edges of blocks can provide "staging areas" for crop-eating species like American robins.

Management strategies

Using multiple scare deterrents, deploying them early in the growing season, and moving them frequently improve the likelihood they will be effective in deterring birds.

Some deterrents, like lasers, work in particular situations. For example, lasers deter Canada geese in low-light situations. However, lasers are not likely to deter many of the pest birds seen in crops during the day. Effigies (dead birds hung in the crop) may deter crows.

Bird deterrent sprays that contain methyl anthranilate should be applied following the label as closely as possible to increase the likelihood of effectiveness. For example, generally they should be applied with foggers and the product should come into direct contact with birds.

Increasing resources for beneficial predators can aid in vertebrate pest management. For example, providing nest boxes for predatory birds can increase their activity in crop areas. One common predatory bird, the American kestrel, preys on rodents, insects, and small birds. However, habitat must be appropriate to attract predatory birds (**see information below**). These types of biodiversity-friendly pest management strategies may be useful in marketing.

Bird management strategies of the future may include unmanned aerial systems.

Take-home messages

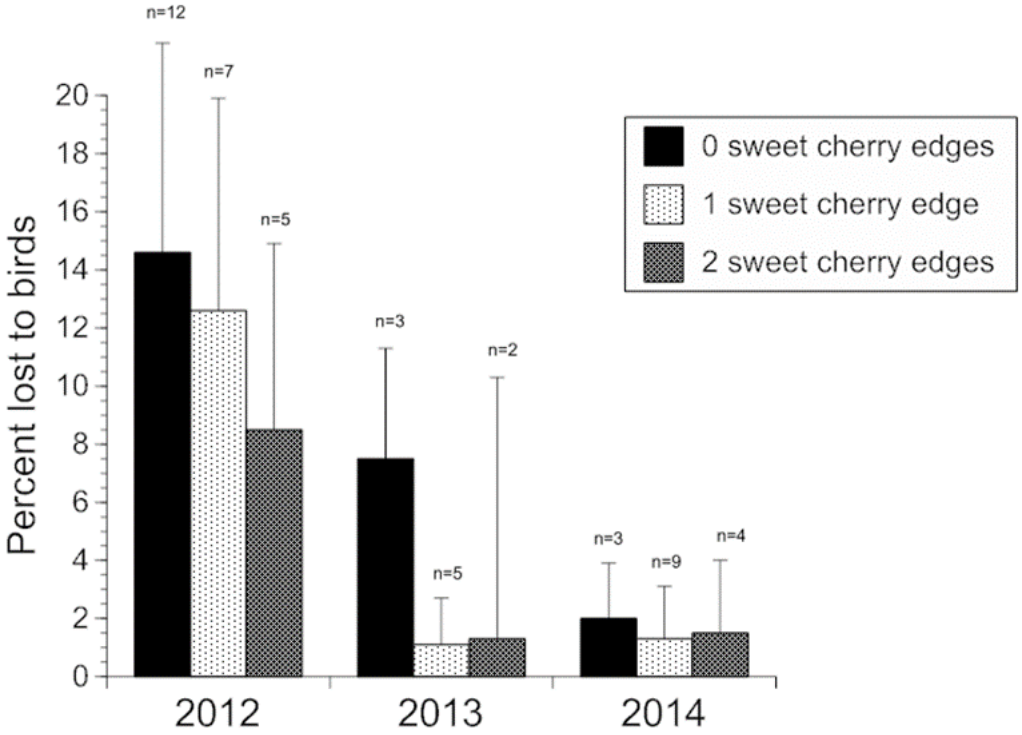
Assess risk
Decrease resources for fruit and vegetable-eating birds
Match number and intensity of deterrents to risk level
Increase resources for beneficial predators

Catherine Lindell is an Associate Professor in Integrative Biology at Michigan State University with a joint appointment at the Center for Global Change and Earth Observations. She investigates strategies to deter bird pests from cropping systems and is particularly interested in how to make agricultural landscapes attractive to species that prey on vertebrate pests. She is originally from upstate New York. She earned her B.A. from Yale and a Ph.D. from Harvard in Organismic and Evolutionary Biology.

Webpage of interest

Bird management planning is addressed in detail in Tracey et al. (2007), pages 211-218, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/193739/managing_bird_damage-full-version.pdf.

Figure 1. Michigan sweet cherries had higher percent bird losses in 2012, a low-yield year, compared to 2013 and 2014, high-yield years, although this effect varied with the number of block edges adjacent to other sweet cherry blocks. In other words, blocks near other blocks are protected to some degree from bird damage.



Installing and Monitoring American Kestrel Nest Boxes

Plans for the Spartan kestrel nest box and mounting tower (designed by Tom Comfort) can be found here: http://www.nestboxbuilder.com/nestbox-article-spartan.html

Additional plans for a simple kestrel nest box can be found here: https://www.peregrinefund.org/docs/pdf/misc/2011-kestrel-nest-box-instructions.pdf

Please consider contributing to the nationwide kestrel nest box monitoring effort by registering your boxes with the American Kestrel Partnership. You can get started here: http://kestrel.peregrinefund.org/begin-obs

Important note:

Kestrels in orchards eat voles and mice, so rodenticides should not be used in orchards when kestrels are present.

Box location

Boxes should be installed away from wooded areas to reduce the risk of occupancy by European Starlings. Open habitat with sparse trees/shrubs is desirable.

Boxes mounted on their own poles/towers can be installed within the orchard itself, either at the end of a row or within a row in an open spot if there is a missing plant.

Boxes should be installed at least one-half mile apart to allow for kestrel territoriality.

Box characteristics
Boxes should be installed 10 – 20 feet from the ground. The box entrance should face the southeast, for studies have shown that kestrel nests are more successful in boxes facing this direction.

Box maintenance
Kestrels do not build nests, so the bottom of nest boxes should be lined with wood shavings or animal bedding.

Boxes that were occupied during the summer should have the wood shavings replaced during the following fall/winter or early spring in preparation for the next breeding season.

If a European Starling occupies a box, it will add grass and other materials to the box and lay 5 – 7 pale blue eggs. An identified starling nest should be removed from the box, and new wood shaving should be added to the box if needed.

By Megan Shave and Catherine Lindell, Michigan State University. Contact C. Lindell for more information: lindellc@msu.edu

ORGANIC SWEET CORN WITHOUT THE WORMS: IT CAN BE DONE!

Jim and Moie Crawford Owners, Jennifer Glenister Farm Manager
New Morning Farm
22263 Anderson Hollow Rd
Hustontown, PA 17229
www.newmorningfarm.net

Overview:
At New Morning Farm we grow sweet corn as part of a highly diversified organic vegetable operation. Out of the thirty acres that are in production each year, corn comprises about 7 acres. This gives us about 17 to 18 weeks of consistent harvests that satisfy several retail markets, plus a modest amount we sell to our wholesale cooperative.

1st Planting Dates – Transplant 4/15, Direct seed 5/20

Plant spacing – Bare Ground 9" in row, 36" between rows

Total Planted – 7 acres

Number of Plantings – 18; .45 A/planting

Direct Seed – MaterMacc planting 8-16

TP Methods – Lannen (carousel transplanter) planting 1-7, 9" in row 36" rows

Waterwheel into black plastic 9" in row, 2 rows/bed about 22" apart

Irrigation – Bare ground: solid set sprinklers, 1"/ week, Plastic: 2 Drip tapes/bed 1+"/ week

Varieties – Xtra-Tender 277A, 378A, 2171

Storage – 32degrees F high humidity; keeps for 7-10 days

Varieties selection:
We select 3-4 varieties based on specific factors that allow us to consistently market high quality sweet corn. We exclusively grow supersweet varieties that have the SH2 gene, as opposed to the SE (sugar enhanced) or SU(sugary) genes. The SH2 varieties have a higher sugar to starch ratio, and the sugars convert more slowly to starch, which means that the kernels are more tender, we have a wider harvest window, and improved storage life. This ultimately allows us to achieve our goal of supplying our customers with a consistently high-quality product at market every week July 4th through October 5th. We also look for varieties that have good ratings for disease resistance. We select varieties that have different days to harvest so that we have the ability to delay direct seeding in the field in the event of weather conditions that prevent tillage and seeding. Our customers like to have different options, so use both white and bi-color varieties.

Fertility:
All our soils are managed for diversified organic vegetable production. Before planting sweet corn, we are especially attentive to Nitrogen and Boron. Sweet corn is a heavy nitrogen feeder, at about 155 lbs per acre. We use soil tests to tweak fertilizer applications, but standard application is 5 tons of organic chicken manure per acre. Using cover

Jennifer Glenister is farm manager at New Morning Farm, a 45-year-old diversified organic vegetable farm serving markets in Washington D.C. After 9 seasons, her responsibilities include overseeing 30 acres of organic vegetable production, managing marketing of the produce, and nurturing a team of 12 apprentice vegetable growers. She has a degree in biology from the University of Vermont.

crops prior to planting corn increases organic matter, and using a leguminous cover crop will contribute to a consistent mineralization of soil N throughout the season. Sweet corn also requires sufficient Boron for good tip fill. We watch the soil tests very carefully and plow-down boron before planting sweet corn. If we start to see tip fill issues in plantings, we would tissue test, and apply more boron in a foliar application with the insecticide spray.

Season extension/consistent harvests:
We seed about the first seven weeks of corn in the greenhouse starting April 1st, and transplant them at 15-18 days from seed date. This allows us to circumvent issues that come with trying to direct seed into cold soil, being poor seed germination and higher pressure from seed corn maggot. The first planting of corn is the variety with the fastest maturity, and on the same day we also seed a variety that will mature a week later. This is our second planting of corn. When we are done transplanting and ready to move into direct seeding into the field, we manage to timing to be able to seed our standard variety(with the longest days to harvest), so we have the flexibility to seed a faster maturing variety later if the field conditions do not allow us to work or if soil temperatures are still low. We want soil temperatures to be at least 55-60 degrees F.

We transplant with either a carousel transplanter into bare ground, or a waterwheel transplanter into black plastic if the soil is too wet for tillage. We aim to have plastic pre-laid to receive at least one generation of corn, sometimes two. Having some plastic ready gives us more flexibility and adverse weather rarely throws the planting/transplanting schedule off.

We cover the spring transplants with row cover, without hoops. The row cover is .55 oz. per square yard, the equivalent of Agribon 19. All row cover is removed from the transplants when threat of frost has passed, usually the last week of May, which is a week or two after we begin direct seeding.

Pest and disease control:
Early in the corn plant development, around tassel, European Corn Borer (ECB) is a concern. We release a biological control, Trichogramma ostriniae, when the plants are 12-18 inches high. This parasitoid wasp usually handles most of the ECB pressure. We purchase Trichogramma from IPM Labs of Locke, NY. When scouting, we use pheromone traps, visual monitoring of feeding damage in the whorl of the plant, and the reports that are found on the Penn State Pest Watch website. Most likely, all generations will need at least one spray application right when the corn is at row tassel. Another application may be necessary depending on the pest pressure in the area and visual monitoring on the farm.

The other main insect pest to monitor and keep in check is Corn Earworm (CEW). Adults of this pest are a pale buff color with a dark spot on either wing, which lay eggs on fresh corn silk. As the eggs hatch, the small larvae crawl into the ear and begin feeding on corn in the ear. This makes the ear less or un-marketable. Monitoring on the farm has shifted from primarily using the PSU pest watch website, to doing our own monitoring on the farm with a pheromone and white heliothis traps. When adults are found in the traps, we make a single application of Entrust suspended in corn oil into the tip of the ear on every plant. This method has been called zealating. This must be done at the proper timing to avoid missing the vulnerable pest or subjecting the ear to other problems.

Using these methods, we can consistently produce high quality organic sweet corn with minimal worm damage if any. Occasionally the timing is a bit off and we see some worm infestation. This is most commonly in 2nd ears which were too immature for zealating.

Three key diseases pose a threat to corn production at NMF. The diseases we have the potential to see are Stewart's Wilt, Rust, and Northern Corn Leaf Blight (NCLB). The varieties of corn that we grow exhibit some resistance to these diseases. Most years, we do not see any disease, however, in the past it has been evident that the white varieties of corn show a lower level of resistance to NCLB.

Weed control:
Successful weed control is largely dependent upon successful timing with a tine-weeder, targeting weeds at thread stage. Often, we see the best control when the first pass with the tine-weeder is shortly after planting, when the corn

has germinated and has a 1-2" root, but has not emerged. In mid-summer, we would tine weed about every 5 days, at least three treatments for each planting of corn. This is followed by belly mounted sweeps when the corn is 4-6" tall. When corn is on black plastic, we use a Hillside Cultivator to maintain weed control on the plastic edges.

Harvest and post-harvest handling:
We begin harvesting corn for markets in the first week of July, hopefully in time to make the July 4th markets, and will continue harvesting weekly into October. Harvest begins at the break of dawn before the sun begins to warm the corn. Three dozen ears are put into a mesh sack, and then these sacks are hauled to a cooler(32-34F) and promptly spread out without stacking any sacks on top of each other. They are left this way for 6-24 hours. This cooling period is crucial for keeping the sugar content of the kernels intact.

Marketing and sales:
Consistently bringing high quality, delicious corn to our markets adds to our credibility for our customers, and allows us to charge a premium price for our product. Successfully and consistently providing this specialty crop has brought people back to our stand again and again.

We purposely overplant in order to be sure to maximize the retail market demand, but we stay within the limits of what can be absorbed through our wholesale market, where we also can claim a profitable price.

INSECT CONTROL UPDATE FOR POTATOES: EVALUATING NEW INSECTICIDES FOR COLORADO POTATO BEETLE

Thomas P. Kuhar
Professor – Dept. of Entomology, Virginia Tech
Blacksburg, VA 24061-0319
tkuhar@vt.edu

One of the most important insect pest problems of potatoes in the mid-Atlantic U.S. is the Colorado potato beetle (CPB), which can significantly defoliate plants resulting in substantial yield loss. At-planting applications of neonicotinoid insecticides such as Admire Pro (or other imidacloprid 2F products), Platinum, Belay, Scorpion, Venom, or Brigadier have been widely used by many commercial potato growers as a cornerstone of their insect pest management programs. These insecticides have a low mammalian toxicity and work extremely well as a systemic insecticide that is taken up by the roots and moved to above-ground plant tissue to kill certain insects that feed on leaf tissue such as CPB and potato leafhoppers.

However, wide-scale indiscriminate use of neonicotinoids globally has brought about various levels of concern and regulatory action, which has caused some growers to seek alternative insecticide to the neonicotinoids. In addition, insecticide resistance to neonicotinoids has appeared in numerous populations of CPB from the northeastern and Midwestern U.S. over the past decade. Managing neonicotinoid resistance in CPB through integrated pest management practices and rotation of insecticide active ingredients is key to sustaining the long-term efficacy of these compounds for potato producers.

Thus, entomologists are continuously evaluating new insecticides for potential use in potatoes and other crops. Herein, I summarize our most recent insecticide evaluations on the Eastern Shore of Virginia, where pest pressure from CPB is high.

The experiment was conducted at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, VA and consisted of 9 treatments arranged in a RCB design with 4 replicates. 'Superior' potatoes were planted on 6 Apr 2015. Plots were 2 rows wide and 20 ft (6.1 m) long with unplanted guard rows on each side. Rows were planted on a 3 ft row center (0.9 m) with 11 inches (0.3 m) between plants, in a 6 tier field design with 8 ft (2.4 m) alleys between tiers and a 16 ft (4.9 m) center alley. All foliar treatments were applied on 20 and 28 May using a 4-nozzle boom equipped with 110003VS spray tips spaced 20" apart spraying 2 rows at a time and powered by a CO_2 backpack sprayer at 40psi delivering 38 gpa. All plots were maintained according to standard commercial practices.

On 22 May (2 DAT) and 27 May (7 DAT), the number of CPB small larvae (SL), large larva (LL) and adults (A) were recorded per 10 stems per plot. On 5 Jun, percentage defoliation was estimated visually for each 2-row plot. On 30 Jun, all potato tubers were mechanically harvested and weighed per plot. Data were analyzed using ANOVA and were arcsine square root transformed prior to analysis. Means were separated using Tukey's HSD at the 0.05 level of significance.

Tom Kuhar is a Professor and Vegetable IPM Specialist in the Department of Entomology at Virginia Tech. Dr. Kuhar's research focuses on the ecology and integrated pest management of insect pests of potato and vegetable crops. He has published over 100 peer-reviewed papers and 6 book chapters on insect pest management in agricultural crops. He received his B.S. degree in biology from Towson, University, Towson, MD in 1992 and his Master's (1996) and Ph.D. (2000) degrees in entomology from Virginia Tech. He formerly worked as a postdoctoral research associate at Cornell University, Ithaca, NY researching alternative methods for managing vegetable pests. A native of Baltimore, MD, he and his wife, Stacey, who have two children, Daniel (15) and Brianna Marie (14).

On 27 May (7 DAT), all treatments had significantly fewer small and large CPB larvae than the untreated check (Table 1). On 5 Jun, all treatments also had significantly less % defoliation than the untreated check, which had virtually all plants completely defoliated by CPB (Table 1). As expected, yield differences were significant with all treatments having 3 to 5 times greater tuber yield than the untreated check (Table 1).

Table 1. Control of Colorado potato beetle with foliar sprays of new insecticides in Painter, VA.

Treatment*	Rate – fl oz product / acre	Mean no. Colorado potato beetles / 10 stems			% defoliation	Tuber yield (in cwt)
		22-May	27-May			
		Large larvae	Small larvae	Large larvae	5 Jun	
Untreated check		63.8	39.8 a	67.3 a	87.5 a	9.9 b
Exirel 100SE	13.5	12.0	2.3 b	1.5 b	0.0 b	40.6 ab
Agri-Mek 0.70SC	2.8	6.3	2.3 b	1.5 b	0.0 b	50.7 a
Minecto Pro	6.1	19.8	9.3 b	14.5 b	10.0 b	42.4 ab
Minecto Pro	8.0	15.5	2.8 b	10.5 b	1.3 b	39.2 ab
Besiege 1.25ZC	8.9	6.5	7.0 b	14.3 b	1.3 b	49.1 a
Blackhawk	3.3	10.8	10.3 b	14.8 b	1.3 b	35.7 ab
Harvanta 50SL	11.0	8.3	1.8 b	1.3 b	2.5 b	30.5 ab
Harvanta 50SL	16.0	16.3	1.5 b	0.0 b	2.5 b	44.2 a
P-value from ANOVA		ns	<0.001	<0.001	<0.0001	0.013

∑ All foliar treatments included the adjuvant Induce at 0.1% v/v.

∑ All data were analyzed using ANOVA. Means were separated using Tukey's HSD at the 0.05 level of significance. Means followed by the same letter within a column are not significantly different ($P>0.05$).

POTATO VARIETY LICENSING AND ITS IMPLICATIONS

Walter De Jong
School of Integrative Plant Science, Cornell University, Ithaca, NY 14853 wsd2@cornell.edu

Three separate legal frameworks exist for breeders (and more typically, their employers) to protect the intellectual property (IP) represented by new plant varieties. The most commonly used in the public sector is **Plant Variety Protection** (PVP), also known as Plant Breeder's Rights (PBR). In the private sector **Utility Patents** are typically used. **Plant Patents** are available for clonally propagated crops, but crops (like potato) that are propagated through tubers are specifically excluded.

All these forms of IP protection confer rights to the owners. Utility Patents are the most restrictive, allowing owners full control over who grows the variety and how it is used. PVP allows the owner to control who can sell, import or export seed of the variety, but does not prevent any other breeder from using the variety to make new crosses ('breeder's exemption'), nor does it prevent growers from saving seed for their own use ('farmer's exemption'). For potato, the protection conferred by both PVP and utility patents lasts for 20 years. Once IP protection expires, the variety can be used without restriction.

Although PVP has been available for seed and hybrid crops since 1970, it has only been available for potato since 1994. Over the past two decades the entire potato community has been slowly, and collectively, appreciating the implications.

The most obvious is that seed growers now need to obtain a license to grow new varieties, as every potato breeding program in the US now routinely applies for PVP on their releases. To obtain a license, seed growers typically need to pay a fee, and also pay a royalty based on the amount of seed sold. For breeding programs at universities the technology transfer office (and not the breeder) oversees this process. Some of the license fees and royalties collected make their way back to the breeding program; for public sector breeders this has helped to mitigate continued reductions in federal and state grant support.

It is possible for PVP holders to license new varieties on either an exclusive or non-exclusive basis. The majority of public sector varieties are currently licensed on a non-exclusive basis, recognizing that public dollars went into their development. Even so, exclusive licenses make sense in some cases, especially where the licensee needs to make considerable investment before the new variety has much value, e.g., a lengthy marketing campaign to build interest in it

Walter De Jong is an Associate Professor in the Department of Plant Breeding and Genetics at Cornell University. At Cornell he oversees the applied potato breeding program and also conducts lab-based research aimed at identifying genes that control important potato traits. Prior to his arrival at Cornell in February 2000, Walter was a potato molecular geneticist at the Scottish Crop Research Institute in the UK. He received a PhD in Plant Pathology from the University of Wisconsin-Madison in 1994. He is a native of New Brunswick, Canada, where his father was a potato breeder with Agriculture and Agri-Food Canada. He is married to Darlene and has two daughters, Hannah and Amber.

POTATO GERMPLASM EVALUATION IN PENNSYLVANIA

Xinshun Qu
Department of Plant Pathology and Environmental Microbiology, The Pennsylvania State University, 405 Buckhout Lab, University Park, PA 16802
Email: xsq1@psu.edu
Robert E. Leiby
Pennsylvania Co-Operative Potato Growers, Inc., 3107 North Front Street, Harrisburg, PA 17110
Email: rleiby@pacooppotatoes.com

Pennsylvania has a long history and tradition of growing potatoes and is one of the leading states in the production of potato chips. However, potato varieties currently grown in Pennsylvania present a variety of problems to growers. Historically, Pennsylvania potato growers have focused on producing chipping potatoes or round white table potatoes. Pennsylvania growers have relied on a few major varieties to meet the needs of the marketplace. Changes in the marketplace have expanded the need for potatoes in many different categories. We now know that there is a market for specialty potatoes, like creamers (potatoes generally ¾" to 1 5/8" in diameter), yellow, red, blue, and purple colored potatoes. Market demands have intensified efforts to find better processing potato varieties beyond potato chips. Fresh cut potatoes for institutional use and fresh cut French fries represent an important component of Pennsylvania market segment. Worldwide, there are thousands of potato varieties that could be chosen to grow in Pennsylvania. Potato variety testing continues to be a very important part of the Pennsylvania Potato Research Program. We conducted potato germplasm evaluation trials on potato growers' farms and on agricultural research fields at the Russell E. Larson Agricultural Research Center in Rock Springs in Pennsylvania. The objective of this project was to find new varieties and breeding clones that have adaptation to Pennsylvania potato growing regions and have qualities that are suitable for either processing or tablestock.

In 2017, we evaluated 229 potato varieties/breeding clones for yield, processing, and culinary characteristics on research farm at Penn State. These varieties were collected from different potato breeding programs from USDA, Maine, New York, North Carolina, Colorado, Oregon, Michigan, Wisconsin, Idaho and private companies. We also had an early season variety trial with 36 varieties and a creamer variety trial with 7 varieties on research farm at Penn State. In Northampton County, we had a variety trial with 32 varieties. In Erie County, we had a variety trial with 40 varieties. We had PotatoesUSA chip potato trial with 14 varieties as one of 12 states in the U.S. that tested new promising numbered chip potato clones. These are clones were developed by USDA ARS and University potato breeding programs. We will discuss promising potato varieties with high qualities for fresh market and for processing under Pennsylvania field conditions.

Xinshun Qu is a Research Associate in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University. His research focuses on potato germplasm evaluation and potato disease management

Robert E. Leiby grew up on a Pennsylvania potato farm. After graduating from Delaware Valley College, he was hired by Penn State Cooperative Extension. He worked in Lehigh County as an agricultural agent and County Extension Director. Bob retired from Penn State Extension after 37 years of service. For the last four years he worked for Pennsylvania Co-Operative Potato Growers, Inc. as a potato crop consultant. He lives near Kutztown, PA, with his wife Jan Marie.

HOW TO CONDUCT ON FARM RESEARCH

Curtis M. Frederick, PhD
Sterman Masser's Inc., 2 Fearnot Road, Sacramento, Pennsylvania 17968
cfrederick@masserspuds.com

Applied research has the potential to greatly improve your operation or greatly misdirect your operation, it depends on how it is conducted. Properly conducted research first depends on refining your question in order to accurately determine the impact of your variables in question. Once a question is determined, the selection of field sites is crucial so as to control for outside influences on your results. Part of this involves replicating your plots so as to accurately measure the effect of the variables in question. Finally, data analysis is the key to bringing this all together and determining how the data answers your question. Here we focus on the above in the context of growing potatoes and ways to test the next product or method that comes to your farm.

Forming your question

Farming consists of many variables that impact your crop and nearly as many people trying to sell you a new product. Here we explore case studies in potatoes that demonstrate how to refine your questions in order to test what might improve your operation.

Site selection and replication

Choosing the background in which you frame your study is crucial in determining a difference in your treatments. One must know the field history and underlying soil characteristics before placing field plots in a field. Here we will examine case studies in order to understand why this matters. Site selection is an attempt to minimize the effect field variation has on your results. In this talk, we will examine how replication is also an attempt to eliminate the natural variation of the fields from affecting the trial results. We will also discuss how improper replication can be abused to show effects that don't exist or misdirect you into the wrong practice.

Analyzing your data

Once you have harvested or observed your treatments, there are many methods to analyze data and perform statistical interpretation. For on farm research however, we are most often concerned with single factor differences, such as fertilizer A vs. fertilizer B vs. fertilizer C. With replication of treatments, we have multiple results per treatment and these are all variable in their response. We will discuss a simple way to compare treatments and take into account the variation of responses.

This talk aims to help you perform an on farm trial and highlight some pitfalls to avoid based on experience learned at the research farm at Sterman Masser's Inc. With better testing, it is hoped that better products and practices for the Pennsylvania Potato Industry can be rapidly adopted in the future.

Curtis Frederick is the Senior Agronomist for Sterman Masser's Inc. since March of 2017. His role involves variety development, research, and education in order to aid the creation of safe, high quality, potato products. He earned his B.Sc. at Penn State (Horticulture '09) and then worked in South Africa as a research project manager and agronomist for the Dr. Jonathan Lynch Root Lab. While there, he not only worked on the root systems of maize and dry beans, but also became engaged to his wife, Rebecca. Curtis later earned his PhD in 2017 in the Plant Breeding and Genetics Program at the University of Wisconsin-Madison under the advising of Dr. Paul Bethke. His research focused on storage quality traits of processing potatoes. A native of Sugarloaf, PA, Curtis and his wife now live in his hometown. They are both taking an active role in Haz-Wald Farms, his family's farm, and Curtis is excited to perform research relevant to Pennsylvania's potato industry.

ASPARAGUS PRODUCTION, MANAGEMENT, AND MARKETING

Carl Cantaluppi
Retired Area Horticulture Agent
NC Cooperative Extension Service
1222 Grangers Rd., Selinsgrove, PA 17870
carl1954@ptd.net

Introduction

Asparagus is a perennial vegetable that is gaining popularity with more customers at farmers markets who ask for the tasty and nutritious vegetable that is very easy to grow, with yields averaging 3,000 lbs. per acre and retailing for $3.00/lb. or more. For over 20 years, new asparagus varieties that have been released are male hybrids. Asparagus is normally dioecious, meaning that it has male and female reproductive structures (flowers) on separate plants. Female plants expend energy to produce seed while in the fern growth stage. Because of this, female plants produce one-half the number of spears than male plants, which produce no seed. Seeds from female plants fall to the ground and germinate, causing a seedling asparagus weed problem.

For this reason, asparagus breeders in the U.S. and other countries have gone with male hybrids obtained from super male parent plants. When these super males are crossed with a female, the majority of the F_1 generation is male, with few seeds produced. These super male hybrids yield about three times the amount of the older dioecious open-pollinated varieties, such as Mary Washington.

Soil Preparation

It is important to eliminate all perennial weed problems at least one year before planting. This can be done effectively by treating the actively growing weeds with a non-selective herbicide. Another way to reduce weed populations and help build soil organic matter is to prepare the field at least one year in advance. This can be done by planting a cover crop such as clover, or an early-maturing soybean variety. The soybeans can then be harvested, or clover can be chopped and plowed down and seeded to winter wheat or rye at 3-4 bushels per acre in the fall before planting asparagus. The cover crop can be plowed under the next spring to increase soil organic matter content before planting asparagus.

Soil test to determine pH and fertilizer requirements. The ideal pH range for asparagus is between 6.7 and 7.0. Asparagus does not tolerate acid soils and will not grow well at a pH of less than 6.0. Also, a fungus disease that contributes to asparagus decline (Fusarium crown and root rot) survives better at a low pH. Liming the soil to bring the pH up to 7.0-7.5 reduces the survivability of Fusarium, especially if asparagus has been grown there previously. Phosphorus and potassium should be provided so that the soil contains 250 lbs of available phosphorus and 300 lbs of available potassium per acre. Phosphorus does not move readily in the soil and cannot be incorporated easily into the soil after the asparagus is planted. Essentially, one must incorporate phosphorus before planting. Also, apply 70 lbs of actual nitrogen per acre.

Asparagus grows and yields best in a deep, well-drained sandy loam soil, but will tolerate heavier soils as long as the soil has good internal drainage and the water table does not come within four feet of the surface. This would interfere with the extensive and deep root system.

Carl Cantaluppi has been an Area Horticulture Agent with the NC Cooperative Extension Service for 22 years. He has conducted applied research with asparagus, seedless table grapes, pawpaws, and rhubarb. He is a native of Ringwood, NJ and received his B.S. degree in Horticulture from Delaware Valley College of Science and Agriculture, Doylestown, PA in 1976. He received a M.S. degree in Horticulture from Kansas State University, Manhattan, KS in 1980 and has worked for Cooperative Extension in Kansas, Oklahoma, Illinois, and Ohio before moving to North Carolina in 1994. He retired with 36 years of service in July 2016 and moved to Selinsgrove, PA with his wife, Ruth.

Broadcast the fertilizer and plow it under when preparing the land for the planting furrows. Then, each year after harvest, broadcast 70 lbs actual nitrogen and other nutrients (if needed) per acre so it will be utilized by the new fern growth to store for the following year's crop. Lime can also be added at this time if needed. Soil test every year for the first four years to determine if fertility and pH adjustments are necessary. Then soil test every two years.

An asparagus crown is the crown and fleshy root system of a one-year-old plant that is grown from seed. Buds enlarge to produce the spear. Buds are arranged in a dominant hierarchy system where the first bud is the largest, and each succeeding bud gives rise to a smaller diameter spear. This is why harvesting needs to stop after a specified period, otherwise, food reserves in the crown will be exhausted.

Planting

Soil temperature for planting crowns should be at least 50 degrees F so that the crowns can start to grow immediately. There is no advantage to planting crowns in cold soils. In fact, prolonged cool, wet soils might make crowns more susceptible to Fusarium crown rot. Crowns can be planted in mid-March in the Coastal Plain, early April in the Piedmont, and in mid-late April in the Mountains if the soil has warmed sufficiently. Growers all over the state can have the entire month of May to plant the crowns, if needed. Do not accept the crowns until the field is ready to plant. **If crowns are received before the field is ready to plant, they have to be stored in a refrigerator between 33-38 degrees. Otherwise, the buds on the crown will sprout, causing the fleshy roots to shrivel and die.**

Apply 200 lbs of 0-20-0 or 100 lbs of 0-46-0 fertilizer per acre applied in the bottom of the furrow before planting transplants or crowns. This is in addition to the phosphorus that was incorporated before breaking the furrows. The crowns are then placed into the furrow, right-side up or upside down, on top of the fertilizer. Crown orientation is not important. However, crowns with the buds oriented upward will emerge faster. The fertilizer will not burn the crowns. If phosphorus is not added at this time, it is difficult to get it down to the roots later because it does not move readily in the soil. Roots literally have to grow through the phosphorus to receive the benefit.

Research shows that pre-plant applications of phosphorus below the crown are an important factor in long-term asparagus production. Omitting the phosphorus placed in the bottom of the furrow will reduce yields in subsequent years as compared with not adding the additional phosphorus.

Asparagus crowns are received in bulk or in bundles of 25 crowns per bundle. After receiving, separate the different sized crowns into separate piles for small, medium, and large. It takes about an hour to separate 1,000 crowns. When ready to plant, plant all the smalls together in the same row, all the mediums together, and all the large crowns together. Do not plant a small crown next to a medium or large sized crown. This will cause the larger one to shade the smaller one, which will never attain its full growth potential.

It's not uncommon to get a 5-6-foot tall fern growth in one season with the male hybrid varieties with ample soil moisture. A five-foot between row spacing is needed because the fern growth is vigorous and will usually fill the between-row space after one growing season if one-year-old crowns are planted. It also allows for better air circulation to promote faster fern drying from rain and morning dews. This helps to delay the onset of foliar fungus diseases.

Use a middlebuster or lister plow to open the soil in opposite directions. On a heavy soil, plant no deeper than 5 inches, on a light textured soil, no more than 6 inches. Research shows the deeper the planting depth, the more large diameter spears are obtained, but total yield is less than planting at a shallower depth.

Crown spacing between crowns in the row can be anywhere from 9-18 inches. Research shows that there is really no advantage of planting 9 inches between crowns in the row. A larger yield is obtained earlier at a 9-inch spacing, but after 4 or 5 years, the yield will be the same as 18-inch spaced crowns in the row. Also, the closer the crowns are spaced in the row, the more crowns are needed, increasing the cost. A crown spacing of 18 inches between crowns in the row with 5 feet between rows would need 5,808 crowns per acre. A crown spacing of 12 inches between crowns in the row with 5 feet between rows would need 8,712 crowns per acre.

Asparagus crowns should not be planted in a solid block; rather, plant the field with drive rows spaced between a block of five rows. An air-blast sprayer is needed to blow insecticides and fungicides into the dense fern canopy from both sides of the five-row block to get good coverage. More rows can be planted in a block if the spray swath can penetrate through one half of the block on one side and can spray into the other half-block from the other side. Boom sprayers usually cannot be set high enough to prevent the knocking over of ferns, which will cause damage.

The furrows can be filled in completely to soil level after planting without damaging the crowns. However, do not drive on or compact the soil over the newly planted furrows or emergence of the spears will be severely delayed or reduced. With good soil moisture, the new spears will break through the soil in 1-2 weeks.

Variety Selection

Varieties that are among the highest yielding and available as one-year-old crowns include Jersey Giant, Jersey Supreme, and Guelph Millennium.

Another variety is Viola or Purple Passion that has purple spears. It is higher in sugar content than green asparagus. When it's cooked, the purple color is lost and it reverts back to green. It is strictly a novelty type. It is not a male hybrid, but is one that might fit into a niche market with a premium price. It is also a prolific seedling asparagus weed producer by the female plants, so watch out for that!

Yields of the California hybrid varieties, including UC 157, Atlas, Apollo, and Grande are similar to the NJ male hybrids and have the attributes of taller spear growth (8-10 inches) with tighter spear tips under warm temperatures. A disadvantage of these varieties is that they do not overwinter well in cold climates, which cause yield reductions over the life of the planting. They have been bred for the warmer, arid climates.

Weed Control

Weed control is very important in asparagus. If young plants compete with weeds, they will stress the plants and prevent them from making good fern growth during the planting year. There is no need to cultivate the soil to control weeds in asparagus. Use herbicides to control weeds. Research shows that even the shallowest of cultivations between asparagus rows cuts and injures roots, predisposing them to *Fusarium* root rot fungus that eventually will kill the asparagus.

Growers can use Linuron or Diuron pre-emergence herbicide to control broadleaf and grassy weeds immediately after the furrows are filled in after planting. This can be applied over the newly covered furrow and between the rows. In the spring, mow off the dead fern about one month before spears normally start emerging. Then tank mix Linuron or Diuron as a pre-emergence treatment along with Glyphosate as a post-emergence treatment.

After harvest is over, the entire field can be snapped, leaving only cut spears. Then apply another tank-mix of Linuron or Diuron along with Glyphosate. If grassy weeds emerge while the asparagus is in the fern growth state, Poast and Crop Oil can be sprayed to control emerged grassy weeds. For broadleaf weed control in the fern growth stage, apply the amine salt of 2,4-D as a basal spray, contacting only the asparagus fern stalk at the base of the plant, without directly contacting the fern.

Asparagus is very salt tolerant and salt can be used to control weeds, but salt will seal the soil surface, impeding water infiltration and percolation. Also, after a heavy rain, the salts can leach horizontally through the soil and can kill other vegetables adjacent to the asparagus which are not as salt tolerant as asparagus.

Harvesting

As previously stated, during the second year, about 4 weeks before the spears start to emerge, mow off the dead fern and spray a pre-emergence herbicide right over the dead fern. Do not cut the fern down in the fall because the dead fern will catch moisture and snow in the winter and it will keep the soil temperature about 5 degrees colder than the temperature of bare soil. This colder soil temperature will delay early spear emergence in the spring when warm day temperatures would force the growth of new spears in bare soil, causing frost injury, making them spoil and be

unmarketable. Mow the dead fern off as close to the ground as possible to prevent skinned knuckles on the sharp dead fern stalks while harvesting.

Under cool air temperatures, (<70 degrees) harvesting might be done once every 2-3 days, harvesting a 7-9-inch-tall spear with tight tips. Over 70-degree air temperature will cause the tips of the spears to open up or "fern out" at a shorter height, which causes fiber development in the spear that makes it tough. Spear diameter has no bearing on toughness. Fiber development is determined by the tightness of the spear tip. Harvesting under warm temperatures forces the grower to pick shorter, 5-7-inch-tall spears, before the spear tips fern out, in order to have tender spears of high quality. This may involve harvesting in the morning and evening of the same day, as spears elongate rapidly under high temperatures.

Research shows that asparagus can be harvested for 2 weeks during the year after planting with no harm. In fact, harvesting for 2 weeks the year after planting stimulates more buds (spears) to be produced on the crown that gives rise to greater yields in future years as compared with not harvesting them until the second or third year after planting.

One can safely harvest for 2 weeks during the second year, 4 weeks during the third year, 6 weeks during the fourth year, and 8 weeks during the fifth year, depending on spear diameter. When 3/4 of the spears are pencil sized in diameter, it's best to stop harvesting, instead of continuing to harvest for the specified number of weeks. This will take some experience in growing the crop to determine this.

Asparagus can be harvested with a knife, below the soil, resulting in a tough and fibrous butt that has to be trimmed off and is not usable. Asparagus grown in western states are harvested with a knife so that the white butt serves as a plug to help prevent moisture loss through the tip of the spear as they are shipped east. Cutting below the soil with a knife increases the chances of cutting into other buds on the crown that would normally produce more spears.

Snapped asparagus contains no fibrous butt since the spear snaps off at the point where it starts to become tough. It is all usable, with no waste. Snapped asparagus should command a higher price than cut asparagus.

Do not allow any small spindly spears that are not marketable to grow into ferns while harvesting. If this is allowed to happen, it provides an excellent site for asparagus beetles to lay their eggs, change into larvae, and into adult beetles. The field should look absolutely clean during harvest, except for new spears coming up or ones ready to be harvested.

Harvesting asparagus can be done by walking and stooping, but is hard on the back. A harvest-aid can be built, which is nothing more than a low-hung cart that people can ride on, leaning forward, snapping asparagus, and placing them in trays on the unit. These can be made by taking a steering mechanism off of a wagon, welding some pieces of iron to form a frame, and building it wide enough to hold 3 people to straddle 3 rows of asparagus. The person in the middle steers with his feet while he picks at the same time, so the driver can help harvest.

Two person hours are needed to pick asparagus by walking and stopping. Using a harvest-aid will reduce the time by about 15-20% and workers are usually content to ride a harvest-aid rather than walk and stoop to pick asparagus.

Harvest asparagus in the morning when the temperatures are cool. It has a very high respiration rate, just like a fresh cut flower. Spears can be harvested into plastic containers that have holes in them to let water pass through, and plunging them into ice-cold water for about 5 minutes. This will take the field heat out of the spears. Then pull them out of the water, let drain, and put them into plastic bags and refrigerate at about 36 degrees F. Storage life at 36 degrees is about 2 weeks, but growers should try to sell the asparagus soon after it is picked, to let the consumer hold it for 2 weeks, if needed.

Marketing

Can asparagus work as a pick-your-own crop? Yes, if one has plenty of field supervision showing customers how and where to pick. One grower uses a 12-quart plastic bucket to pick into that is about 7" tall. He instructs customers to put the bucket down next to the spear. If the spear is at least as tall as the bucket or taller, it can be picked. Most growers sell asparagus unsorted as field-run asparagus and put them in plastic bags. Others will sort them by spear diameter. Some will place one pound bundles of asparagus bunched with a rubber band in a tray of standing water to keep them fresh, if selling retail to the public at a farmers market.

Growing White Asparagus

White asparagus, grown in the absence of sunlight, is sometimes desired by specialty restaurant chefs, and are known to pay 3-4 times the price of green asparagus. Opaque 55-gallon drums can be cut in half lengthwise, and butted up against each other down the row. To harvest, lift up the drum to harvest the white asparagus, and then put it down. After harvest season is over, remove the drums and allow the spears to turn green and elongate into ferns.

Insects and Diseases

Cutworms feed on the spear tips at night before emerging from the soil. They feed on one side of the spear, causing the tip to bend over. They can easily be controlled with approved insecticides.

Asparagus beetle adults will chew on the fern, stripping off the green material and reducing photosynthesis, causing a loss of stored food reserves in the crown for next year's crop. They also lay eggs on the spears during harvest. The best way to control them during harvest is to pick on a timely basis and never let any spears get tall and spindly, or allow them to fern out.

Asparagus growing north of the 40° latitude across the U.S., will be conducive to asparagus getting asparagus rust. South of the 40° latitude is conducive to *Cercospora* needle blight which is more commonly present in the Midwest and Southeast. These are both fungus diseases.

Cercospora spores are blown in the air during the summer, when it's hot and humid. It turns the needles of the fern yellow, then brown, and then they fall off. This severely reduces the photosynthetic capability of the fern to manufacture carbohydrates to move down the plant into the crown for next year's spears.

Alternate sprays of Mancozeb and Chlorothalonil fungicides once a week from mid-July to late September to control *Cercospora* and asparagus rust. Neglecting to spray will severely reduce spear yield the following year. Burning the old ferns off instead of mowing them off and letting the residue remain on the ground will not stop spears from getting *Cercospora* or rust. All it will do is delay the start of the disease by about one week. So be prepared to spray, regardless if the old ferns are burned or not.

Fusarium crown and root rot is the major destructive disease of asparagus and the one that usually takes fields out of production. There are no controls once the plants succumb. The main way to prevent from getting it is to prevent stresses from occurring to the plant. These stresses include overharvesting, low soil pH, low soil fertility, frost damaged spears, waterlogged soil, and insect, disease, and weed problems.

The best time to fertilize is right after harvesting is over. This will allow the fertilizer to be used by the new fern growth to allow the translocation of nutrients down to the crown for next year's spears. Soil test every other year to determine your fertilizer and lime requirement.

New Asparagus Publication is Now Available

Carl Cantaluppi has announced his new publication entitled, "Asparagus Production from A to Z". It is a comprehensive 68-page regional bulletin that covers the planting, growing, harvesting, and marketing of asparagus, including a budget with costs and expected income per acre, for the serious commercial asparagus grower. The bulletin includes 25 color photos of insects, diseases, and planting techniques to aid the grower. The author is an asparagus expert with over 30 years of applied research experience, having worked with asparagus in the northeast, mid-west and southeast U.S., with variety trial information being reported in those areas.

Other interesting topics in the bulletin include:

- A detailed study of asparagus varieties
- Results of a ten-year replicated variety trial in NC
- White asparagus production using opaque covers
- Handling, grading, and storage
- Marketing methods
- Estimating spear growth of asparagus as affected by temperature
- Yield increases as influenced by judicious fungicide applications

The bulletin is bound with a plastic spiral binder with a clear plastic front and green back cover. It sells for $25.00 and includes shipping and handling. To order a copy, send a check or money order in U.S. dollars for $25.00, payable to Carl Cantaluppi and mail to:

Carl Cantaluppi
1222 Grangers Rd.
Selinsgrove, PA 17870

Asparagus Crown and Seed Sources – 2018

Walker Plants, Inc.
105 Porchtown Rd.
Pittsgrove, NJ 08318
856-358-2548
856-358-6127 FAX

Nourse Farms, Inc.
41 River Rd.
South Deerfield, MA 01373
413-665-2658
413-665-7888 FAX

Daisy Farms
28355 M-152
Dowagiac, MI 49047
269-782-6321

Ron Richter Farms
Rt. 2
90487-60th St.
Decatur, MI 49045
269-423-7339

Krohne Plant Farms
65295 CR342
Hartford, MI 49057
269-424-5423
269-424-3126 FAX

DRONE MAPPING & SCOUTING -AGVUE TECHNOLOGIES

Paul Caskey, AgVue Technologies

AgVue Technologies provides advanced analytics, crop management data and solutions to farmers and growers worldwide. AgVue uses unmanned aerial systems (drones) flying at low altitudes to capture high resolution images to produce detailed plant health maps, digital surface maps and 3D images. These images help growers make better crop management decisions typically leading to a 3-5% increase in yield, while reducing total costs.

Using traditional scouting methods, it's not possible for farmers to evaluate every acre of every field. Areas of poor health can easily be missed by walking a limited area. Even in the areas viewed by the naked eye, plant stress can be missed that becomes apparent when viewed in non-visible near infrared (NIR) and infrared (IR) spectrums.

Drones make it possible to "see" every square foot of a grower's crop. When a drone flies a mission over a crop, hundreds of images are taken at low altitude. The images are stitched together to create a high-resolution orthomosaics of the field. The mosaic, comprising visible and non-visible wavelengths, can generate dozens of different maps showing relevant vegetative indices (VIs) for early detection of crop health issues, better crop/soil management and estimation of harvest yield. Comparing week-to-week, month-to-month and year-to-year data helps analyze the efficacy of prescription applications over time.

Precision agriculture techniques give farmers better data about their crops to maximize yield, quality and chemical usage. The actionable data provided by low-altitude images let the farmer closely monitor crop health and determine chemical prescriptions and where to put them. Putting the right amount of chemicals in just the right places is critical to crop health and chemical cost savings.

A vegetative index (VI) is a measure of plant health determined by comparing reflectance at different wavelength of light using basic algebraic formulae. The Normalized Difference Vegetative Index (NDVI) is probably the most well known of the VI's. While NDVI is a good indicator of plant health, there are dozens of other narrow-band and broadband vegetative indices that show a wide range of plant stressors, including moisture, nitrogen, chlorophyll, insect damage and weeds.

Classification of plants by reflectance value or VI index provides another set of data about crop health. With a typical ground resolution of approximately 2.4 cm/pixel, a small area of a plant, weed or soil can be captured, isolated and classified. The classification software will then show every pixel in the field mosaic with a similar wavelength profile. This is extremely effective in identifying areas and percentages of a field that have healthy plants, stressed plants, weeds, canopy cover, bare soil, etc.

In addition to vegetative indices, images captured by drones can create digital surface maps and 3D images. Digital surface (topo) maps can indicate drainage issues and identify areas where water might pool or run off too quickly. 3D images show plant height canopy size and biomass, giving farmers more data to determine plant vigor, water usage and harvest yield.

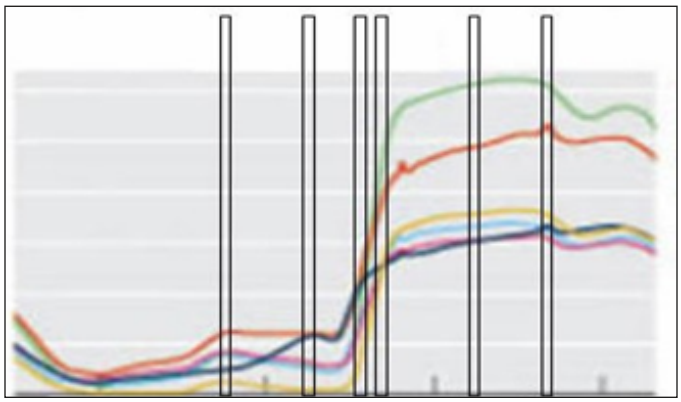
Paul Caskey is co-founder and Vice President of Technology at AgVue Technologies. His role at AgVue is management of design and development of custom unmanned aerial vehicles, firmware design and backend image processing. Paul received a BSEE from Penn State University, with a concentration in microwave engineering. He has an entrepreneurial background and was the founder and president of Laser Vision, Inc. and then subsequently Omnivision Telecommunications, Inc. Both Laser Vision and OTI manufactured equipment for high-capacity point-to-point communications. After OTI, Mr. Caskey formed Enterprise Networks, a service company using custom designed microwave equipment to deliver high speed internet to businesses in Philadelphia and Los Angeles.

Paul has been a lifetime aviation enthusiast. He received his private pilot's license shortly after graduating high school and has logged over 1,000 hours of flight time.. He has also been building and flying model aircraft since childhood. Combining his love of aviation, with his strong technical background and extensive experience with startup companies, Paul formed AgVue Technologies, with Cheryl Sigg. Cheryl is the president of AgVue Technologies and has a Bachelor of Science from Penn State College of Agriculture.

APPLICATION OF DRONES AND MAPPING – WHERE IS THIS GOING?

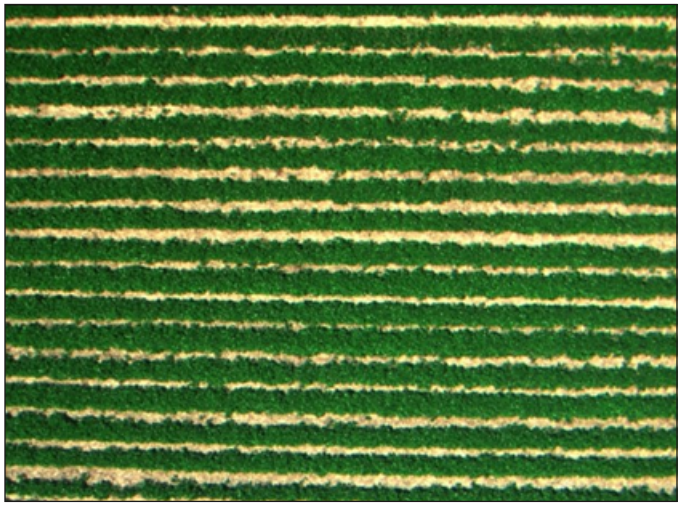
AgVue uses a 6-band calibrated sensor purposely designed to their specifications for agricultural imaging. The graph below shows typical bands captured and the spectral response of several different plant species. The images captured by AgVue's sensor can calculate over two dozen narrowband and broadband vegetative indices revealing a wide range of crop health issues

AgVue 6-band sensor response

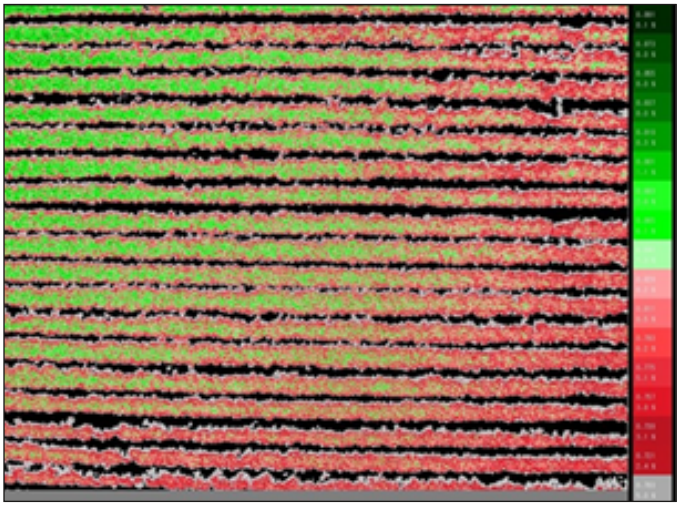


Vegetative Indices Calculated:

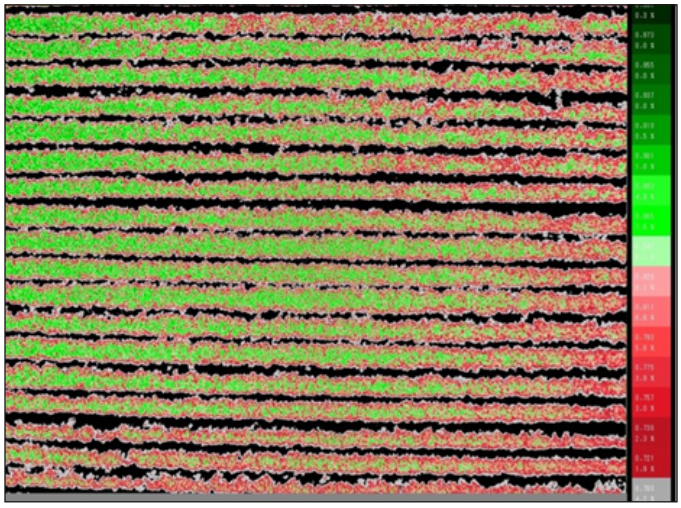
Narrowband	Broadband	
MCARI	NDVI	LAI
MCARI2	ARVI	MNLI
MRENDVI	ENDVI	MSR
MRESR	GEMI	NLI
MTVI	GARI	OSAVI
MTVI2	GDVI	RDVI
RENDVI	GNDVI	SAVI
REPI	GRVI	TDVI
TCARI	IPVI	VARI



Red, Green and Blue (RGB) bands are used for a visible light image of the Strawberry field

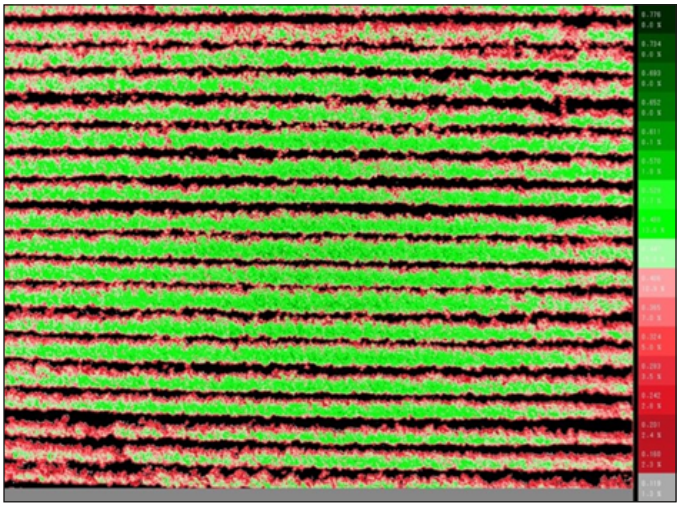


Atmospherically Resistant Vegetative Index (ARVI) gives more contrast than the NDVI image, better highlighting areas of stress



The NDVI image shows areas of vigor and areas of stress. The scale on the right side shows the index represented by each color as well as the percentage of the field with that index value.

A canopy segmentation tool was used to isolate the strawberry canopies from the soil



Soil Adjusted Vegetative Index (SAVI) removes soil artifacts from below the plant canopy. This index offers data relating to biomass and estimating plant harvest yield. It's interesting to note the areas of greatest biomass are not necessarily the areas of highest plant vigo

EC MAPPING: WHY SHOULD WE DO THIS?

Justin Croner, GrowMarkFS

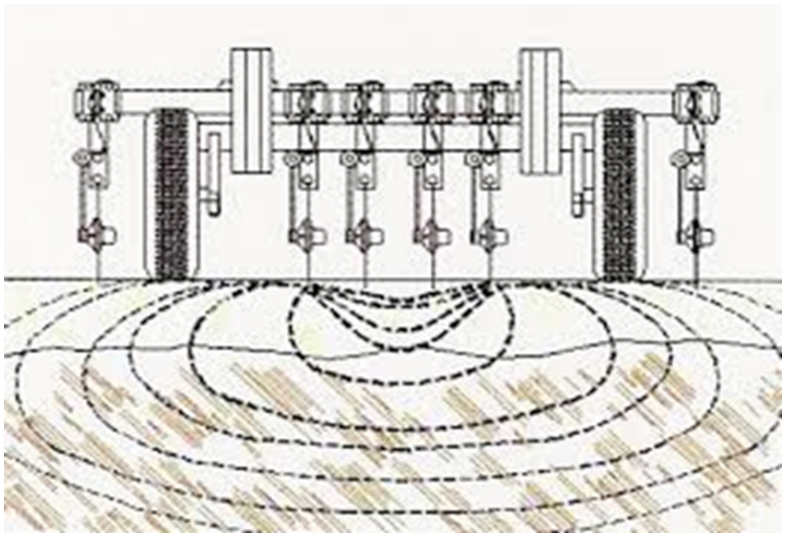
Field variation is a major yield and quality robbing factor in crop production. New technology in application equipment has given us the ability to address field variation. A piece of application equipment can now change the rate of product automatically based on its GPS location. Every field has some variation. Bigger fields will vary more. If you use a composite sample on a 20 acre field you are likely over applying nutrients on one area and under applying on another area.

There are several methods used to divide a field into management zones. This can be done using square grids (10 acre, 5 acre, 2.5 acre, etc.). Soil type maps can be used to create zones. If the grower has a yield monitor they can take years of yield data and overlay them to make zones. Another way to make management zones is through the soil's EC value.

EC stands for Electrical Conductivity. This is the texture of the soil. These zones are determined by use of an EC mapper. One manufacturer of this type of tool is Veris Technologies in Salina, KS. The Veris EC mapper is a small implement equipped with several coulters (*Figure 1*). It is pulled through fields or orchards with the coulters penetrating the soil a few inches deep. Some of the coulters transmit electricity while others measure the voltage drop (*Figure 2*). The machine measures the amount of current that passes through the soil at two depths (12" and 36"). It records 50-100 samples per acre. Each sample is logged as the GPS coordinate where it is collected along with the shallow and deep EC reading in mS/m (milliSiemens/meter). If there is more moisture, in the soil, more current passes through the soil and gives a higher EC reading. If the soil has less moisture then it will record a lower EC reading. It doesn't matter how moist the overall ground is. The readings will all go up or all go down based on the amount of water. The high EC will always have more moisture in it than the low no matter what that overall field conditions would be.

Figure 1:

Figure 2:

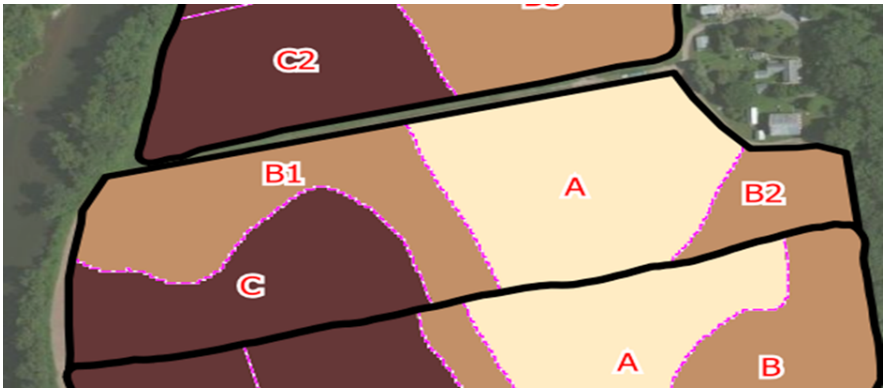


Justin Croner is the manager of MiField Analytics team at Growmark FS LLC. The MiField team works with growers to utilize data and technology to increase yields. Justin has been with the Growmark FS and the Mifield group since 2015. Prior to that, he was a salesperson for a manufacturer of agricultural, mining, and construction equipment. Along with his brother and father he owns a hog finishing, cattle backgrounding, and crop operation in Somerset County, PA.

APPLICATION OF DRONES AND MAPPING – WHERE IS THIS GOING?

When the data is combined and mapped you have a soil texture profile of that field (*Figure 3*). It is broken into three EC zones (High, Low, and Medium). These zones are relative to that field. Even though the soil may be fairly consistent there will always be a high EC and low EC zone. The high EC zone contains more clay and holds more moisture than the rest of the field. The low EC may contain more sand content and may pass more water through it. It is not a judge of the quality of the soil just its characteristics. In a dry year the high EC soil will carry more water and may perform better. In a wet year the low EC zones will carry excess moisture away. The same theory applies to nutrients. Soils with different textures will hold or leach nutrients differently.

Figure 3:



The EC mapping process only needs to be done once on each field. Those soil characteristics will not change unless you were to take 12" to 36" of top soil off of that field.

The next step in the process is to soil sample based off of the newly created zones. A sample is pulled from each zone and analyzed. The zones are sent and GPS points marked where the samples are taken. Every time the field is sampled we can go to the same area and take the same sample. Now that we have the field broken into management we can build recommendations that allow us to place the right product at the right rate in the right areas.

EC mapping is one that is grounded in good science and if applied correctly can increase yields.

Benefits of EC mapping:

- One time through the field to develop zones
- Zones do not change
- Management zones are based on a **soil characteristic, not random**
- The EC map layer allows you to better manage **Water-holding capacity, Nitrogen use and loss, Rooting depth, Drainage, Cation-exchange capacity, Action of soil-applied herbicides, Nematode activity, Loss of mobile nutrients, pH—buffering capacity**
- **Follow the process through and increase yield by decreasing field variability**

COMMUNICATE TO LEAD

John P. Wodehouse
Penn State Extension

Executive Summary
Effective leadership communication in the workplace requires a keen understanding of the relationships between the leader, the follower, and the various contexts (situations) in which the communications are conveyed. Whether speaking, or listening to customers, employees, general managers, finance managers or investors, different styles of verbal and non-verbal approaches may be necessary to ensure the intended meaning of the message is sent, received and understood. This Leadership Communication program is intended to help you identify your leadership communication style, hone in your communication skills and build up your leadership abilities to better convey your intended message in one on one situations, in small groups and while in public speaking in large groups settings.

Learning Objectives;

- Describe the three main factors of effective leadership communication
- Discuss and explain leadership communication styles
- Determine how to choose the most effective leadership communication style in different contexts and situations

Studies show that successful leadership communication skills do not come naturally. While some people are inherently better with communication, language use and motivational story-telling than others, sending a message that is received as intended, in which empowers others to action, is essentially a skilled and learnable process (Harris, Barnes. 2005). For improved leadership communication, enjoy these tips, tactics and strategies.

Practice active listening; Set a goal to really listen to what other people say and focus your concentration on their verbal and non-verbal words and cues. Verbal communication misunderstandings can arise from a variety of sources such as interrupting during the communication, losing focus on the communicator and even by framing the concept in a way that the decoder does not connect with other distractions such as implicit bias and dissonances related to cultural norms and thinking traps (Fairhurst. 2005). When cultural differences exist among employees and leaders, it is important for each to show respect to the culture. When leaders use ineffective or non-relevant metaphors and slang terms that folks from different culture may not understand, or words and phrases with dual (or more) meanings, misunderstandings may also arise. To reduce the possibility of communication misunderstandings while relaying tasks, work orders or instructions, be sure to be clear and concise with instructions and use words in the most basic of terms. *Have there been situations where you find yourself needing to recall details of a conversation, however, when you try, you cannot remember them? What listening skill behavior changes might you try to reduce this from happening?*

John P. Wodehouse knows agribusiness. A Pennsylvania native, he fell in love with agriculture while growing up and working on farms in Columbia County. With 22 years of industry experience in agricultural, facilities management, and landscape nursery, John is in his fifth year with Penn State Extension. He provides community development and agribusiness assistance, as well as entrepreneurial and leadership development programs for producers. John holds a Bachelor of Business Administration and Finance from Albright College and he obtained an Associate in Landscape Nursery Science from Penn State University. Currently, John is achieving a Master's in Leadership Development from Penn State University. In his role with the Penn State Extension Business Unit, John has a proven track record of helping people with resource management and business planning. Two lovely children keep John very busy, they are both active boys, ages ten and twelve. Having been married for 18 beautiful years, John has strong appreciation family values and farming.

Lead by Example; Recent studies in Leadership Development theory exhibit that people and employees replicate the verbal style and to some extent the values styles of their leaders (Denning. 2005). Become aware of the verbal and non-verbal behaviors of your managers, other co-workers and leaders all across the organizational chart. Leaders should be open change agents to the ideas of employees and they should recognize that they are setting an example of their organizations' culture. Communication behaviors to avoid include using slang, swearing on the job, or anytime while at work, or in meetings. If the leaders are unresponsive to concerns and questions, they are sending verbal and non-verbal cues that diminish company attitudes and decrease employee motivation to achieve results. Messages may be misunderstood if the leader relays instructions in a less than positive tone of voice or if they talk down to people or certain employees over another. The communication styles necessary for each employee may differ. Remember to use a nice tone, and talk to others with respect. They are likely to return the behavior back to you. Because some people learn differently than others, try to diversity communication approaches to include written, oral and when applicable; use pictorial charts and diagrams. *Try to think of a time when you felt you were modeling someone or a certain leadership trait or characteristic they exude? Please explain.*

Change Up Your Communication Style; In different situations, such giving work orders to employees, talking to investors, choosing the right combination and style of words is important. Knowing the audience and identifying with their individual and shared interests, values and ethics is beneficial for engagement and meaning. Which style do you have? Can you think of situations in which you change or modify your approach? The main leadership communication behavior styles include;

Directing; leader provides clear role definitions step by step instructions for task completion

Coaching; leader sells the project/task by emotionally supporting and empowering the follower

Delegating; leader passes responsibility to the group, mentors and holds them accountable

Supporting; the leader provides some direction and empowers, motivates and supports the team members to achieve their best self.

References:

Yukl & Tracey, (1992). Leader Influence Tactics.

Denning, Stephen. (2005). Transmit your values: Using narrative to instill organizational values, Chapter 6. *The Leader's Guide to Storytelling: Mastering the Art and Discipline of Business Narrative* (pp. 121-148). Edison, NJ: John Wiley & Sons.

Fairhurst, G. T. (2005). Reframing the art of framing: Problems and prospects for leadership. *Leadership, 1*(2), 165-185.

Harris, J., & Barnes, B. K. (April, 2005). Leadership storytelling: Learn how to get people to connect with you. *Leadership Excellence, 22*(4), 7-8.

USING THE RECORDS YOU HAVE TO MAKE DECISIONS

Robert Goodling
Dept. of Animal Science, Penn State Extension
324 Henning Building
University Park, PA 16802
Phone: 814-863-3663
Email: rcg133@psu.edu
Tuesday afternoon, January 30, 2018

Proceedings Presentation Summary:

There's a famous quote from Dwight D. Eisenhower that comes to mind here, "farming looks mighty easy when your plow is a pencil and you're a thousand miles from the corn field."

It's easy to think we're just going to set up our electronic record-keeping system and all our records and finances will be in perfect shape. Yet when you actually have to determine your goals and needs and adopt the right routines and learn the systems, things can get complicated.

When using different record management systems it's important to keep this in mind. You need to really think about what you're trying to capture with the system. Ask yourself:

- What do I need to get out of it, or what does our business require?
- How can I engage with it without getting inundated with data entry?

Obviously, we don't have our products, be it livestock or vegetables, directly telling us what we need to do necessarily from time to time if we're not collecting the right data. We don't have our herd dairy cows calling us saying, "Hey, I'm going to be dropping in production," or our tomatoes texting to say "The adjusted watering rate is just what I needed." The same goes with our financials. We don't necessarily have our financial system telling us, "Hey, this is what I need you to do to generate that great current balance sheet that your lender is requesting for that new loan."

In today's data rich business environment, too many operations are still information poor. We track our income and expenses for tax purposes, but do we marry that data to yield data to look at cost per bushel or product level revenue generation? Are pesticide records kept in such a way that they can be used to predict disease pressure or assess current cropping rotations? Here are three general areas your business already has data on in one form or another:

- Financial data
- Yield/production data
- Pesticide application/records

Robert Goodling is currently an Extension Associate in the Department of Animal Science and a member of the Penn State Extension Dairy Team. His primary focus is farm and data management and record keeping. Rob was raised in portions of central and southern Pennsylvania. Rob attended Penn State University from 1997 to 2001, graduating with a degree in Animal Science, Science Option. He then obtained a Master's Degree in Dairy Science from the University of Wisconsin-Madison. Rob's masters work was in the field of dairy genetics. Upon graduating from UW in January 2004 and before joining the Department in April 2011, Rob worked for the Animal Improvement Programs Laboratory, an ARS-USDA office responsible for dairy cattle genetic evaluations and selection research, and was the Dairy Extension Educator in Lebanon County from 2004 to 2011. Rob's family is still actively involved with the dairy & crop industry both here in PA and in WI. He resides in Lebanon, PA with his wife Erin, and their two sons, Robert and Lincoln.

Each of these areas have existing data serving basic business needs: tax reporting, insurance reporting (i.e. crop insurance), pesticide records, etc. Likewise, good records can simplify reporting efforts, such as GAP/GHP audits, FISMA requirements, organic certification, etc. There are a lot of resources available to help with operational management and streamline data entry and information extraction. Here are just a few of the more popular ones available today:

- Penn State Extension Ag Alternatives (https://extension.psu.edu/business-and-operations/business-management/ag-alternatives?p=4)
  - A collection of production articles with general overviews, key production steps, and sample budgets. Great for evaluating potential new ventures
- Penn State Extension Spray Record-Keeping (https://extension.psu.edu/spray-record-keeping)
  - Designed for orchard applications. Helps record various applications (nutrients, pesticides, disease monitoring, etc.), rates, as well as working safety information needed for pesticide licensing.
- Penn State Extension "Models of The Future" (https://extension.psu.edu/catalogsearch/result/?q=models+for+the+future)
  - A series of case studies and production practice spreadsheet tools to evaluate current and future production systems, primarily in fruit and vegetable production.
- GFP Veggie Compass (http://www.ssawg.org/gfp-veggie-compass/)
  - A spreadsheet that encompasses financial records and production records and provides various outputs integrating the two. A resource for small scale operations, or those just starting to understand the dynamics between production and finances.
- AgSquared (http://www.agsquared.com/)
  - A smartphone/tablet application that can help plan, manage, and record all the various stages of fruit and vegetable production. Has a free limit use version, then varying price structures depending on features needed for the business.

Regardless of how you're tracking the data (even paper records are great), the key is to not stop there. Review the data available to determine production trends, or evaluate labor needs to become more efficient. The bottom line is to use the data to generate useful information that increases your understanding, and can drive or justify management changes to help the business prosper.

WHAT DO EMPLOYEES WANT?

John Berry, Penn State Extension

Although money is the most often cited reward folks desire from their work, near 60% of the respondents to a recent poll report (Deloitte, 2017) formal benefits and informal "perks" greatly impact their employment decisions.

The top five economic desires of employees:

1. Pay
2. "Good" health insurance
3. Work / Life balance
4. Potential for professional development and advancement
5. Sense of "meaning" in the work

Over 25% of employees "would quit this year".

Almost 70% of employees "expect to leave" in the next two years.

Frequent voluntary turnover has a negative impact on employee morale, productivity, and company revenue. Recruiting and training a new employee requires staff time and money. According to the Bureau of Labor Statistics, turnover is highest in industries such as trade and utilities, construction, retail, customer service, hospitality, and service. (Zane Benefits, 2016)

Cost of replacing an employee?

16% of annual salary for high-turnover, low-paying jobs (earning under $30,000 a year). For example, the cost to replace a $10/hour retail employee would be $3,328.

20% of annual salary for midrange positions (earning $30,000 to $50,000 a year). For example, the cost to replace a $40k manager would be $8,000.

(Center for American Progress)

Penn State Extension, Educator with broad responsibilities centered on agricultural marketing, farm management, and business transition. John is in his 20th year with Penn State Extension having come out of dairy production previously.

Associates degree in Dairy Science from Delhi Ag & Tech, Delhi, NY

Bachelor's degree in Animal Science from Tennessee Tech University, Cookeville, TN

Master's degree in Business Administration from Kutztown University, Kutztown, PA

45 of 60 credits towards a doctorate degree in Adult Education, Penn State University, Middletown, PA

Certified Farm Business Transition Coordinator, International Farm Transition Network

John and Maureen have been married since 1975 and are quite proud of their three young-adult children, their spouses, and three grandchildren. We are all active and engaged with a desire to help each other and the community in which we live and work. The entire family is crazy over dogs.

The best part of my career with Penn State is the opportunity to develop long term relationships with any number of farm families across the northeast and mid-Atlantic states. Getting to know a wide range of individuals working in a diverse set of conditions has been great. I enjoy helping where I can, but more significantly I value the chance to listen and understand what people are experiencing and what they see as their future. I find that occasionally I can be of assistance in achieving their goals.

The real costs of employees leaving?

- The cost of hiring a new employee including the advertising, interviewing, screening, and hiring.
- Cost of onboarding a new person, including training and management time.
- Lost productivity—it may take a new employee one to two years to reach the productivity of an existing person.
- Lost engagement—other employees who see high turnover tend to disengage and lose productivity.
- Customer service and errors—for example new employees take longer and are often less adept at solving problems.
- Training cost—for example, over two to three years, a business likely invests 10 to 20 percent of an employee's salary or more in training
- Cultural impact—whenever someone leaves, others take time to ask why. (Josh Bersin)

RETIRING FROM THE FARM

Juliette Enfield
Penn State Extension
100 Dillon Drive Youngsville, PA 16371
jse15@psu.edu

"Studies show that over two-thirds of retiring farmers do not have identified successors and nearly 90% of farm owners neither had an exit strategy nor knew how to develop one." *Parsons, R. et al. University of Vermont. The FarmLASTS Project. April 2010. www.uvm.edu/farmlasts. Accessed Oct 18, 2016*

Extension has the tools to help you get started on your transition plan. Transitioning the farm isn't an easy task, but planning ahead can make it easier. As cheesy as it sounds, the creation of a vision, a timeline and goals set for a farm transition is critical. Research has shown that 80% of farming families hope to pass their farm to the next generation but only 30% of farm businesses make it to the second generation and 12% make it to the third. Without a solid plan in place for the transfer of assets slowly over time, farm successors may have just as many challenges purchasing the farm's assets as if they were brand new to the farm. If you have identified successors, will the farm assets be equally split among the successors or will these assets be split based on the work that each successor has done on the farm, or will the split be based on their financial need? There are worksheets available that can help you to calculate the dollar value of a labor contribution to the business. Some farm businesses have no successors and are ready to liquidate all assets and get out of the business completely. In both situations, the farmers who are ready to retire should create a budget of expected income and expenses during retirement years. A financial advisor can help you estimate how much money you should set aside to cover the cost of your medical expenses and long term care. Although this can seem scary to think about, you or those you will depend on are ultimately responsible for this cost, and you don't want to leave behind a legacy of debt. Retirement income comes from four sources: off-farm investments or IRAs, income from the farm as a partner or employee, social security payments, or the sale of farm assets. The first step in transitioning the farm is to obtain updated financial records that show all assets and liabilities of the farm. With the help of professionals such as a tax accountant and an estate planner, you will be able to make informed decisions about your options for keeping tax payments low while transferring assets in the way that your family has planned.

Juliette Enfield is a farm business management educator with Penn State Extension. She has a Masters Degree in Horticulture from New Mexico State University and has worked on organic and hydroponic vegetable farms in the northeast and out west.

Since joining Extension in 2013, she has been the course coordinator and instructor for *Farm Sense©*, Penn State Extension's course on farm financial management. As an agricultural business educator, she works with new and beginning farmers regularly to answer questions they have about starting a farm business. Juliette regularly teaches *Food for Profit*, a one day workshop that introduces food entrepreneurs to food safety regulations, marketing strategies, and business planning. She also teaches *Exploring the Small Farm Dream*, a course that helps aspiring farmers determine whether or not farming will be a feasible endeavor for them. She has written several informational articles on agricultural business management topics based on most frequently asked questions from Extension clientele. She guest speaks and teaches farm financial management and agricultural business marketing at various educational events across Pennsylvania.

THIRD PARTY AUDITS – WHERE WE'VE BEEN AND WHERE WE'RE HEADED A WEGMANS PERSPECTIVE

Steve Strub, Manager Produce Food Safety
Wegmans Food Markets, 1500 Brooks Ave., P.O. Box 30844, Rochester, New York 14603

Where We Have Been:

In 2003, a Hepatitis A outbreak at a Chi Chi's restaurant led to 600 sicknesses and 3 deaths, followed by the 2006 spinach/E.coli O157:H7 and the 2008 salmonella outbreak that was thought to be linked to raw tomatoes but was subsequently linked to jalapeno and serrano peppers, at a great loss to the tomato industry. We all think of produce as healthy and good but every outbreak diluted the positive image we had of produce and consumers were beginning to think that produce is something you needed to worry about. With the seriousness of these outbreaks and the threat posed to our consumers, Wegmans began a program for GAPs training for our local growers in 2004/2005, working with the National GAPs program at Cornell University, land grant universities, USDA and state Dept.'s of Agriculture due to our concerns about Food Safety and small growers. Our first training was in New York in January 2005 and wasn't always greeted with open arms. In July 2006, Wegmans sent a letter to all our local growers informing them that GAPs would be required to keep doing business with us. In 2007, we collaborated with Rutgers University and the USDA to expand training to our New Jersey growers, and in 2008 we began to focus on GAPS for high risk items (leafy greens, tomatoes, cantaloupes, etc.). Other industry actions began to drive the call for commodity specific guidance such as the LGMA which developed their own set of metrics that the Leafy Greens industry currently follows. The Jensen Farms listeria outbreak in cantaloupes in 2011 was much bigger than previous outbreaks and Wegmans found we had sourced this product through a vendor. Wegmans then decided to divide products into 3 "Safety Tiers" based on risk and stores were limited on what they could purchase from Local distributors with risk items only coming from a Wegmans distribution center and that ALL fresh produce items would need to have GAPs documentation. In 2012, we asked growers to be audited to the Harmonized GAPs standard, with our goal being to ask for one standard for produce audits that major buyers would accept. To help our growers afford these audits and to help emphasize to importance Wegmans placed on these audits, we have supplied our growers with a $500 yearly refund upon submission of passing audit documentation. We also asked that all our National suppliers submit yearly audits to us from a GFSI accredited audit scheme.

Where We Are:

While Wegmans has continued to build on this foundation, the impending FSMA Produce Safety rule has recently made us look at what we currently are requiring from our growers. We have expanded our Grower trainings to all 6 of the states that we currently do business in. The Postharvest Handling and Sanitation Rule of the FSMA Produce Safety Rule will require producers that have a packing house type of facility to better monitor their facilities so starting in 2017, we have asked our growers that have a Packhouse -type facility to complete both the Pre-Harvest and Post-Harvest sections of the USDA Harmonized audit in preparation for possible upcoming FDA inspections of their facilities. While we ask growers new to Wegmans to audit to the standard GAP/GHP level their first year of doing business with us and then step up to the Harmonized Level by their second year, we have had a small percent-

After completing my degree in Dairy management at Cornell University in 1986, I returned to my family's dairy farm as a Partner/Owner for a little over 9 years. Looking for a career change, I joined Wegmans in November of 1996. I have now been with Wegmans a little over 21 years and have enjoyed many varied opportunities in my career. I began as a Produce team leader and became a Produce manager about 18 months later. For the next 10 years, I was a Produce Manager at 6 different Rochester area stores. Included in this timeframe was an opportunity to train in the produce warehouse as an inspector. In 2007 I had the opportunity to work in Front -End store management and spent almost a year in the position. In the spring of 2008 I accepted a position as a Farm Manager at the Wegmans Organic Farm and spent about 18 months helping to get the farm established. In 2009 I was offered the position of Rochester Zone Produce Merchandiser, coordinating Produce Initiatives, Merchandising and over-seeing our Local Grown Program within our 25 store Rochester/ Southern Tier area. I had been the division Homegrown Coordinator for about 5 years when I heard about the opening of our newest one-of-a-kind venture, The Wegmans Cheese Caves, and spent about 2 ½ years managing the start-up of that Facility. In 2016 I was given the opportunity to become Manager of Produce Food Safety and continue to hold that position here at Wegmans Food Markets.

age of our growers continue to audit at the Standard GAP/GHP level. Staring this year- we will no longer reimburse growers after their first year of growing with us for a standard GAP/GHP audit. If they do not step up to be audited at the Harmonized standard then they will not receive our grower audit refund. We hope that this financial incentive will help to get all our growers to adhere to the Harmonized standard by their second year of growing for Wegmans. To help growers cover the cost of the added Post Harvest section and in a response to the increasing costs to our growers of having these audits performed, Wegmans has increased its annual reimbursement to $600 per grower. We continue our policy of accepting any GFSI accredited audit form any of our local growers who need to use audits other than USDA Harmonized to better fit their needs (such as our apple growers that use Global GAPs)

Beginning in next year's 2018 growing season, Wegmans has decided to adhere to a one farm- one audit policy. While most our growers already follow this approach, we have had a few Co-ops in Pennsylvania audited under a Harmonized Quality Management System group GAP program. There has been increased emphasis on the USDA's Group Gap Audit system to help small and mid -sized producers afford audits, pool resources and implement food safety training within their membership. From our experience with the Harmonized QMS system with the Pennsylvania Co-ops, Wegmans can see the value in the Group GAP approach to new, small and mid-sized producers. Wegmans will support the Group GAP standard for first year growers with Wegmans who use the Group GAP approach to help implement their Food Safety Program with the understanding they will graduate up to a one farm- one audit program by the second year of doing business, with hopes that our audit refund policy helps to alleviate their cost concerns.

Where We Are Going

Wegmans is currently looking at several new technologies to help expedite our audit collection process. In order to be more FSMA compliant we have had to find ways make our audit information more easily accessible and less cumbersome to manage. Here are three possible solutions we are currently investigating….

1. Wegmans EDGE-
    A. Currently used by Wegmans Brand Group to collect audits and share product specifications with suppliers
    B. Have just completed process of downloading all national suppliers into the system
    C. Wegmans monitored but supplier driven, each supplier given 2- hour training on how to sign up and down-load audits- burden on growers to maintain
    D. Grower will receive updates when audits are expired or past due, also has section to download product specifications
2. Blockchain-
    A. Wegmans one of about 15 Foundation Partners of the IBM Blockchain Initiative
    B. Worked with Dole, Driscolls and Tyson on initial traceability project
    C. Loop holes found in current GS1 and PTI compliant labeling- not all warehouses and distribution centers set up to handle all the labeling requirements. Wegmans would have to develop labeling specifications for suppliers if we move forward
    D. Information owned by all who are part of the system- once information downloaded it cannot be changed.
    E. Increased transparency and traceability "From Farm to Fork" and enhanced re- call capabilities
    F. Ability to trace back to single suppliers-possible prevention of whole industries being wiped out from outbreaks

G. Danny Wegman's Vision- customer scanning package at store level and be able to trace to path of that product to the farm/field it was grown

H. Growers need access to smart phone and computer to participate

3. Trellis-

A. Developed by Purdue University in partnership with the Produce Marketing Association (PMA) -uses a Blockchain based framework.

B. Supports most widely used audit schemes, can analyze audits for answers to key questions, corrective actions and deficiencies and cut down wasted time collecting audits

C. Free and open source- no cost to growers

D. All audit bodies will have to implement- auditors will have permission to download your audit information to the system immediately upon successful completion of audit, taking burden off grower to follow up and forward results.

COMMON MISTAKES ON A 3RD PARTY AUDIT

John Mast
Quality Fresh, LLC
8097 Ore Hill Rd SW
Stone Creek, Ohio 43840

What are the biggest challenges growers face in passing an audit?
The biggest challenges often occur in the very first audit and usually include leaving out individual areas that need written standard operating procedures, (how you do it), and records. These areas include Traceability, Worker Health & Hygiene, Agricultural Chemicals, A Water System Description, Post Harvest Uses Of Water And Related SOP's, Animal Control, Soil Amendments, Tools & Equipment.

Traceability is a system by which any given produce can be tracked to the buyer. Who bought it, what day it was sold, what day it was packed, what day it was harvested from what field. Traceability also includes being able to trace backwards one step for items such as seed, transplants, soil inputs, chemicals, etc.

Worker Health & Hygiene includes farm policies and records of worker training about hand washing prior to working with produce, where toilet facilities are located, glove use if necessary, where break areas are located, and that workers who show signs of illness or have exposed cuts should not be handling produce.

Agricultural Chemicals consist of records such as date of application, application rates, and what water source was used to mix the spray. Agricultural chemical use should always comply with label instructions. Include the EPA ID number and your Applicator License number as well when required.

Water System Description includes all water sources and what you are using them for such as pond water being used for drip irrigation. It is important to be detailed about POST HARVEST WATER, (water used for washing produce and washing hands). You will need a current water test, a written description of the produce washing process, and water change schedules when tub washing. Detailed SOP's are needed for all sanitizer used in the produce washing process whether it is used in an injector on a wash line, hand mixed in a tub, or mixed in an overhead tank. Don't guess. Be accurate. All sanitizer used must be labeled for washing produce and have instructions for use on the label.

Animal Control. Describe what you do to control wild and domestic animals in your growing areas and what the procedures are if there is animal damage. Include pests in the packing house with a description of trap use and records.

Soil Amendments are mostly record keeping. Keep complete manure records including what kind and when it was applied. Also keep records of fertilizer applications and their dates. Drip line records are recommended.

Tools and Equipment. Identify items that may contact produce and write cleaning and sanitizing procedures and schedules.

What are Things farmers have done that make it easy for you/them?
If you address the above items and keep good records you are well on your way to passing an audit. Using an audit template, and there are many out there, can make it easier to write your food safety plan. However, I don't care what form it is in as long as I can find the necessary items.

John Mast is an Auditor and conducts 3rd Party Audits for Quality Fresh LLC located at 9825 Cleveland Avenue, Magnolia, Ohio. He has been trained in the Harmonized Standard, and Canada Gap audit systems but feels that the Harmonized Standard is a very good standard for the small grower. He conducts audits primarily in Ohio, Michigan, Indiana, and Kentucky. He is a native of Holmes County Ohio and lives in the area with his wife Mary Ann.

What are things farmers have done to make it difficult for you/them?
The most difficult thing is when a farmer does not prepare in advance, but uses the audit time for the auditor to tell him what he needs to do to be compliant. The farmer clearly cannot pass the audit that day. The auditor writes up his non conformity issues and gives the farmer an agreed upon amount of time to come into compliance. The problem with this approach is that you now have to write up all the documentation to correct the non-compliance issues, and this has to be done when you are growing, picking, and packing produce. I don't have to tell you that you are busy enough at that time of year without writing pages of SOP's and sending them to me to try and become compliant. I am also very busy in the produce season and I do audits all day and then come home and have to deal with the non conformity issues that are in the mail. It's a slow process and you are much better off not going that route. Prepare now in the off season when you have more time.

What do farmers worry about unnecessarily?
Farmers usually worry that they are not going to pass the audit. If you prepare in advance using the above items as your guide, you will probably pass the audit.

What should farmers focus on more?
In my opinion, not just farmers but the industry as a whole should spend more time teaching the problem-solving and math involved with treating produce washing and hand washing water that does not pass the potability test. Virtually all water that does not pass the potability test can be made potable if treated effectively but farmers very often don't know how to do it. More time needs to be spent teaching the skills required to figure out and correct water problems.

2018 FOOD TRENDS TO KEEP CUSTOMERS ENGAGED

Heather Manzo, Penn State Univ.

Get ready for the upcoming season! Consumer food trend reports are issued annually by commodity groups, commissioned by top food processors, and completed by well-respected consulting firms. These reports influence all aspects of the global, domestic, and regional food systems in ways we may not realize when wearing our 'farmer' or 'food producer' hats. These consumer trend reports influence what you will see when wearing your 'consumer' hat while watching cooking shows, 'new' menu items in restaurants, what the 'hot' chefs are making, and even which 'new' flavor of snack chips will be on the shelf.

Considering these national and global food trends can assist farmers and value added food producers to keep product lines fresh, uncover and pursue new niche markets or products and therefore potential revenue streams. Perusing these previews early in the market season can assist with seed selection and inspire seasonal flavors for all manner of value added goods, farm market and farmers markets.

The 2018 Food Trends List:

Flavor Profiles from Persia, Morocco, Syria and Lebanon

These warm, smoky, often savory with sweet flavors will be featured. These cuisines rely heavily on fruit, vegetables, herbs and whole grains and make for great grab and go snacks at market, or as ready to eat in a market's prepared section. Think beet hummus, eggplant and garlic dip and tabbouleh salad featuring tomatoes parsley, garlic, cucumbers, onions and whole grains. Moroccan food often features hearty vegetable stew studded with fruit, slow cooked in a clay pot called a *tagine*.

Anything black - charred and fire kissed

Argentinian Celebrity Chef Francis Mallmann introduced his elemental cooking method to the world in Netflix's '*A Chef's Table*'. Restaurants with open fire pits are opening around the country. These restaurants are often open to farm to table relationships, and need to source protein and produce that can withstand flame.

Mushrooms

Mushrooms have captivated the human imagination for millennia, showing up in folk art and as *medica media* in cultures around the world. Mushroom powders, tea and infusions will show up in unusual places. Creative cooks and value added producers may choose to include fungi as a star ingredient in craft products like ice creams, and sweet and savory fusions.

Heather Manzo works for Penn State Extension with a focus in agricultural marketing, business planning, community development, and supply chain optimization in regional food systems. Her work focuses on assisting value added food entreprenuers, small-scale wholesalers, and small to medium size farms maximize profits and define customer bases. She is Chair of the Pittsburgh Food Policy Council, a collaborative working group that envisions a food system that benefits our community, our economy and our environment in ways that are equitable and sustainable. Prior experience includes organizational sustainability coordinator, farm manager, and green industry educator. She hold a MSc in Agroecology, a BSBA in Marketing, and a fondness for fostering innovation and profitability, practices Permaculture and tends to grow pumpkin patches in her front yard.

Ugly produce

Seconds are having a field day as consumers show an interest in reducing food waste. Food rescue CSA's are popping up in PA and around the country, purchasing seconds from farms. Entrepreneurs are starting juice businesses with the twisted sisters. Food banks have additional funds through the non-profit Feeding America to acquire seconds from farms. Food artists and photographers have given these misshapen fruits and veggies a makeover by creating funny faces out of them and photographing them. Surf the web for examples of this trend.

Coffee based cocktails

Maybe it's the winter warm drink season, or an homage to *The Big Lebowski,* but fusion drinks featuring coffee are going to become more prevalent on drink menus. Find the drink trendsetters who regularly need herbs and fruits to balance these concoctions.

Plant engineered meat substitutes, like 'heme'

Heme is found in plants and animals, contains iron, and has been combine with vegetable and grains to produce a new vegetarian 'meat' for burgers, meatballs and meat loaf that is more environmentally and cholesterol friendly than animal protein. It has the juicy characteristic of meat, that soy or all-grain subs cannot replicate accurately. Chefs making these concoctions will need all manner of pickled and fresh accoutrement to dress this product, as well as potatoes and wheat to make it.

It's Raining TACOS

Tacos are more than a kid friendly Parry Grip song. Tacos elevate the Central American flavor profile that has trended for almost half a decade. Taquerieas, taco truck and brick and mortar restaurants will be looking for everything needed to make a good taco: protein, eggs, potatoes, garlic, onions, cilantro, garlic, peppers and tomatoes to keep customers satisfied.

AGRITOURISM AT HIGH ALTITUDE RHUBARB

Dennis Duncan, Owner/Operator
High Altitude Rhubarb—Organic Farm & Nursery
7275 Wildridge Rd.
Black Forest, CO 80908
(719)494-8424
Dennis.Duncan@HighAltitudeRhubarb.com

This talk presents our experiences and plans to market and sell fresh rhubarb and plants via agritourism. We'll first discuss the nature of our farm. Then we'll discuss our initial approach to agritourism and our current operation. Lastly, we'll discuss future options and plans. Details of our growing techniques are presented in a separate talk, *Growing Rhubarb in Colorado.* Additional information is also available at www.HighAltitudeRhubarb.com

The Farm

High Altitude Rhubarb is a certified-organic hobby farm at 7700' in the semi-arid, zone 4-5 climate of Black Forest, Colorado. First harvest was 2008. We have always been an agritourism destination. Our primary crop is fresh rhubarb, which we sell by pick-your-own. We also sell rhubarb and horseradish plants which are picked up before or during the harvest. Black Forest is a semi-rural area (minimum lot size 5 acres). We are one hour's drive from 1.5 million people in Denver and Colorado Springs but a minimum of 15 minutes from any town or city.

Current output is 3000 pounds. Newer plantings not yet in production will yield at least another 4000 pounds. Less than an acre is planted but it is spread out over 2 acres to create a welcoming ambiance with lots of open space and trees. Rhubarb grows in plots of 80 plants interspersed between Ponderosa pines, which grow sparsely in what was horse pasture. Seedling beds are nearby but compost piles and such are sequestered behind trees.

The Ramp-up

It took several years of experimentation, research and growing to create a plot of rhubarb satisfying our goals and constraints. We opted for pick-your-own over selling to a grocery chain for numerous reasons. Selling to a chain would require additional work, staff, paperwork, equipment, supplies and overhead plus risks inherent in having only one customer. Pick-your-own agritourism was a successful experiment.

In anticipation of hosting many farm-ignorant folks we removed or mitigated as many opportunities for injury as reasonable. One big plus to being organic is the absence of toxic materials on the plants, the soil or around the property. All farm equipment is stored in the barn during the harvest. We took out additional liability insurance should someone be injured during the harvest. This is a strategic issue and should be given careful consideration before launching any agritourism venture. On a negative note, plan as if you expect predators looking to "get hurt" as a way to steal your farm. You must be circumspect about the casual dangers on your farm. You'll have no defense if you leave pitch forks out for the kids to play with…

Dennis created and, along with his wife Donna, owns and operates High Altitude Rhubarb—Organic Farm and Nursery, in Black Forest, CO. A baby boomer, born in '49 in Albuquerque, NM. Raised in Albuquerque and LA, a city boy until age 40. Has lived and worked in NM, CA, NH, TX, MA and CO. Life paused by the Vietnam War, he was a Korean interpreter for NSA. Attended U of MD, U of WA and graduate from the U of NM in Math, BS, and Computer Science, MS in 1978. His computing career saw him as a department chair, engineering and product development manager, director and exec at UNM, Digital Equipment Corporation, Apollo Computer and Eastman Kodak, respectively. His teaching career included UNM, U of Colorado, and Pikes Peak Community College. Moved to Colorado where he says he taught part-time and mismanaged his investments. Trying to find something useful and fun to do with his 6 acres he started the farm in 2002. Current hobbies are dominated by the farm, working and researching farming and rhubarb. To quote him: "It is a rare day when I don't learn something new. Of course, at my age I could be re-learning the same thing every day, how would I know?"

We mow the field to contain weeds and eliminate weed seeds. This has the added benefit of creating a park with islands of rhubarb amongst the trees. We don't water or fertilize the field around the crop. Mowed prairie. The surrounding field is normally brown by the time most crops would come into harvest. Another plus for choosing rhubarb. Also, the rhubarb plots grow in islands of soil in a deep sea of mulch, 12-30" deep, with mulch-covered walkways all around each plot. People don't get dirty picking our crop and it is hard to run in deep mulch. Picnic tables with umbrellas are scattered around, each in its own copse of trees to offer some privacy. We have traditionally advertised that we have bathroom facilities only for emergencies. There is always at least one such emergency and we cheerfully escort them into the house. This is about to change as you will see in "future plans".

Planting rhubarb sufficient for 3000 pounds, bringing water to the field and creating facilities adequate for crowds of a few hundred people required an initial cash outlay of about $2000. In the first three years we plowed most revenue back into the farm to expand the plantings and facilities (Picnic tables, benches, tents, scales, wagons, baskets, tables, signs, umbrellas and other paraphernalia associated with outdoor leisure.) Indeed, the cash flow from the farm has funded all improvements since the initial cash outlay. Of course, this meant a much slower growth in capacity and ability than possible with additional funding. A personal choice.

One of the drawbacks to a pick-your-own venue is the inability, even inadvisability, of trying to moderate customers behaviors. They need to be free to pick and buy whatever they want. This means the best plants are picked to the ground each year. Therefore, rhubarb need to be mature, at least 4 years old, ideally 5, for such abuse not to adversely influence future years harvests. Our current output is 3000 lbs. but current plantings should yield at least an additional 4000 pounds once in production.

Agritourism is a fast-growing segment of the ag market but still novel enough to catch the attention of local news media. In the first three years we ran ads in all the nearby small-town papers. We've had a web presence since day one. Indeed, although only 400-500 people visit each year our website gets 30,000 hits. We've also established a Facebook presence, though it just duplicates information from the website. Facebook is particularly important for your younger customers. Advertising in Denver and Colorado Springs was too expensive, and we didn't yet need that exposure. Indeed, we turned down opportunities for free, national exposure. We are a destination business and mustn't run out of product…a drawback to our initial small scale. We had to discover and create this market, so we are pleasantly surprised by that situation. As it happens, another local newspaper does an article about our novel operation almost each year. We will hopefully be noticed by the Denver Post after an increase in capacity. We have not advertised for years.

We were initially open for a few consecutive weekends, manned only on the first one with extra help. We also supported picking by appointment and shipped both fresh rhubarb and plants. That helped keep us alive in the early years. It also let us work out the kinks before the current crowds began to participate.

The Harvest Festival

Customers dubbed it the "Harvest Festival" because there is a festive atmosphere. We communicate harvest dates via an email list of 1000 people and postings at Facebook and the website. Besides the initial announcement email we send two reminders, the last the day before the harvest. The same information is posted at Facebook. We are open Saturday and Sunday, 8am-2:30pm. We must close at 2:30 because of thunderstorms. To be frank, we're pretty worn out by then anyway. 400-500 people typically attend the harvest, most on Saturday. We don't make our email list available to spammers nor do we send spam ourselves, just harvest and plant info.

We charge no admission. Our money is made on rhubarb, honey, rhubarb cookbooks and plants. We sell out of everything in one weekend. We bottle honey gathered by an area beekeeper. We resell "The Joy of Rhubarb" cookbook. We also resell, with no markup, processed foods made from our rhubarb. This last policy is a courtesy and added benefit for our commercial customers. We normally sell out of all honey, 10 gallons in 2017, cookbooks, 40 in 2017, and commercial products.

We now must limit commercial sales to 20% of the harvest. Past commercial customers include a winery and several Colorado food processors. Price for 200+ pounds is $3/lb. if they pick it themselves, which everyone does…one drove here from another state! The other 80% is sold at wholesale prices to end users at $3.50/lb.

Harvest planning involves: 1) secure staff, mostly volunteers (takes 10-12); 2) announce the harvest weekend as soon as Mother Nature decides; 3) buy 10 gallons of local honey and ensure an adequate cookbook inventory; 4) ensure the scales are certified, insurance is paid up, all government licenses and reports are current, etc., and 5) handling plant sales and distribution as well as email harvest announcements.

As the festival approaches we: 1) mow and groom the grounds, removing dead branches from trees and any farm paraphernalia from the fields; 2) prune all trees of any dead branches, 3) set up a tent for sampling and sales, 4) set up a leaf-removal station, 5) make a final pass over the crop to remove any flower heads or unsightly growth; 6) put up all signs; 7) prepare complementary treats for the customers; 8) bottle the honey, 9) set up coolers with complementary bottled water, teas, and soda , and; 10) have help show up an hour before we're scheduled to open so they can be oriented (We don't have a door to close. Customers show up well before we open and asking them to sit in their car is counter indicated.) and assigned a primary task. The week before harvest is a very busy time.

Commercial pickers come the Friday before the commercial harvest. We set up two tables, one with a scale, boxes and recording material and another for leaf removal. We typically have two helpers work alongside the pickers. One will remove leaves and pack boxes while the other helps the pickers. Commercial pickers come in groups of one to four people.

Public picking is 8-2:30 Saturday and Sunday. Whenever we open, customers will begin arriving at least 30 minutes earlier. I keep myself free to deal with whatever comes up as well as giving tours and answering questions about rhubarb and the farm. We have baskets and wagons to help with the harvest. We specifically ask that nobody bring knives. We remove all leaves at a leaf-whacking station. That station feeds into two checkout lines. At the checkout lines customers are offered free rhubarb treats made the day before, rhubarb tea, and samples of honey and whatever else we are selling. Lines can be long early Saturday, up to 20 people. Shorter now that we have two checkout lines, which required 2 scales and an extra helper or two. We don't generally need both lines after noon on Saturday and never need them on Sunday. We take credit cards, checks and cash. In 10 years of business we have had one check bounce. Credit cards are via an accessory attached to a smart phone. About half of our sales are credit card. Plants are actually paid for in advance of pickup so at the harvest we just check names off a list as people pick them up. Most plants are picked up before the harvest.

Future Plans

We plan significant increases in our rhubarb capacity. We already have plantings adequate to double or triple output, once mature. Besides the organic growth of a satisfied customer base there are numerous other distribution channels, including restaurants, mail orders, special events and farmer's markets. Increased capacity will also allow expansion of the commercial customer base. Capital improvements will include a permanent storage and sales shed.

Starting in 2018, we will experiment with hosting a general farmer's market coincident with the harvest. Running a farmer's market ourselves would be diseconomical. Instead, we're working out a deal with an established market operator to locate his first-of-the-season market on our farm. Besides the added draw, there are several benefits. The market will include live music, face painter, and portable toilets. Also, it partially mitigates the risks of being a destination business. The operator will handle all related insurance and advertising. We just provide the venue.

Lastly, Colorado recently passed an agritourism law which indemnifies agritourism operations from liability for injuries resulting from the normal risks inherent in farming. We must display signs to that effect whenever customers are on the farm. This removes a major barrier to entry for Colorado agritourism. There is also a new Colorado Agritourism Association. We hope they will be a good source of information and advice.

FROM THE GROUND UP

Oley Valley Organics
Mike and Barb Dietrich
516 Oysterdale Rd
Oley, PA 19547
484-336-9980
www.info@oleyvalleyorganics.com

Background

- Started our organic produce farm- fall 2007

Specializing in asparagus, strawberries, garlic and some seasonal vegetables. Everything was sold at the farm or wholesale to restaurants, and other farmers that took their produce to NYC or Philadelphia.

- Feb 2017, our tenth year in business, we opened up a year round organic/local store four miles from the farm which focuses on local produce, meats, milk, cheese and many other products.
- Currently we have over 40 local vendors and continue to add more.
- Our area has many great local growers and producers. Since starting our farm we always wanted to open a year round store to help local producers sell their products and as a one stop shopping experience for our customers. Most farms only sold at farmers markets or had a seasonal stand at their farm which was limiting for both the farmer and the consumer.
- Our goal is to connect farmers and producers to the consumer and for the consumer to know where their food comes from and how it is raised.

Steps to opening the store:

- Develop business plan.
- Did market research.
- Went through a bank for a small start up loan. After the process we decided to finance it ourselves.
- Licensing- state, food handling…
- Insurance- Business, workers comp…
- Accounting- (farm vs store)
- POS system. Which one to use.
- Shelving- Used vs New, metal vs wood…
- Township regulations and permits…
- Store signage
- Store hours
- Number of workers

One Stop shopping experience as well as a destination.
We determined before we opened that just selling local would not pay all the bills. Buying from local farmers and producers is expensive even at wholesale prices. We could not get the full mark up that we needed. So we researched national companies and determined to use KeHe. They sell a lot of organic products and their monthly minimum order was doable for us to meet. Having a national company to supply items that we could not get locally allowed for two things. First, the customer could have a one stop shopping experience and secondly we could get a mark up on those items to offset the low markups on our local products.

- Currently we have over 40 local vendors and continue to add more.
- Most recently we added wines from a local vineyard.

Other income streams at the store:

Greenhouse:

- We grow our farms certified organic plants and the rest we sell.
- Events draw customers

IE: Free pictures with Santa, wreath making classes, open house with samples or meet the farmer…

Some struggles:

- Manning the store as well as the farm as one spouse works another job off the farm.
- Not owning our own building.
- When and how to expand. The current building has limitations.
- Financing growth.

LUCKED OUT ON A GREAT LOCATION

Charles (Charlie) W. Smith III

In 1907 when my great grandfather acquired the original 35 acre tract of land that became T.S. Smith & Sons Inc.. I'm sure he couldn't have imagined the prime location for a farm market he had bought. The original Packing House built in 1928 and still in use today was built on the corner of that property along which was then the major North-South road in Western Sussex County. In the 1950's a modern dual lane highway was built thru the eastern half of the property thus giving us a prime location for a farm market. With the development of Sussex County rapidly changing and the Delaware Beaches becoming more and more popular, we finally took the plunge and built another farm market to capitalize on these changes. Having only been open six months at the time of this talk I can tell you it has been quite a journey. The talk will expound on this journey. Being the only commercial apple grower in our county certainly give us an opportunity to be different from any other farm market around us. I feel we have an exciting challenge ahead of us and I look forward to it.

Charles W. Smith III (Charlie) is a fourth generation fruit grower and co-owner of T.S. Smith & Sons, Inc. His primary responsibilities include managing all aspects of the fruit production, asparagus production, external farmer's markets and the new T. S. Smith Orchard Point Market.

Charlie has a Bachelor of Science Degree from the University of Delaware in Entomology and Applied Ecology. Mr. Smith graduated from Woodbridge High School. He resides in the original farmhouse which was designed as Delaware Century Farm in 2011. His hobbies include fishing and music, leading member of his band, "Charlie and the Cooltones."

COMMUNICATING FOOD SAFETY ISSUE TO YOUR ADVANTAGE

Meredith Melendez
Wesley Kline

Human pathogen outbreaks associated with fresh produce are a reality. Human pathogens can be transferred from one person to another through the surface of produce that is consumed raw. This is most commonly done through the fecal-hand-oral route of contamination. Scientific progress has allowed for greater understanding of the human pathogens that can be found in the farm environment, the spread of these pathogens and the potential for multiple illnesses relating to contaminated produce. Farmers are interested in producing the highest quality fruits and vegetables, and this must include understanding the human pathogen risks on their own farm and the development of risk reeducation measures.

Recent large-scale outbreaks involving human deaths relating to the consumption of fresh produce items received a lot of media attention. The 2006 E. coli outbreak on California spinach impacted the spinach market on the east coast. The outbreak was specific to California spinach from one farm, but the consumer gut reaction was to stop purchasing spinach entirely. This is devastating for farmers nationally, and fluency in food safety risks on your fam and the methods you are using to reduce those risks can bolster consumer trust in your products.

Farms selling produce wholesale are likely more aware of food safety regulations and purchaser demands. Wholesale buyers may communicate with farms that a third-party audit is required in order for them to purchase produce. There are many types of audits available and the buyer of the produce will indicate what they expect from the farm. Farms already completing third party audit inspections will want to advertise this certification on marketing materials and websites to attract new buyers. Most wholesale produce growers will need to comply with the Food Safety Modernization Act Produce Safety Rule. Attendance as an approved FDA training for this regulation will be mandatory, with a timeframe dependent on the size of the operation. Farms achieving compliance with the training requirements and required practices should communicate this to their buyers if not already in communication with them about the regulation.

Direct market producers of produce are more likely to encounter questions from their customers about pesticide residues and GMOs. Continued media attention to large scale produce recalls due to human pathogen contamination increases the public's awareness of issues and will ultimately lead to questions at the farm stand on the topic of human pathogens. Attending an Extension run Good Agricultural Practices training can help farms identify risk areas at the farm, develop risk-reduction practices and allow for a greater comfort level in answering customer questions on the topic.

Understanding commonly used terms relating to food safety on farms is important for developing and communicating your farms food safety practices. This glossary highlights a few definitions, found in the Produce Safety Alliance Grower Training Manual.

Cleaning – Physical removal of dirt (soil) from surfaces which can include the use of clean water and detergent.

Clean break – A break in production where all the food contact surfaces on the production line are cleaned and sanitized with a documented, verified, and validated process.

Composting – A process to produce stabilized compost in which organic material is decomposed by the actions of microorganisms under thermophilic conditions for a designated period of time at a designated temperature, followed by a curing stage under curing conditions.

Meredith Melendez is the Agricultural Agent for Rutgers Cooperative Extension of Mercer County. She has worked for Rutgers Cooperative Extension since 2006, working with Mercer County agricultural producers since 2010. Meredith is responsible for agricultural educational outreach and research in including beginning farmer outreach, organic production systems and on-farm food safety. Meredith is a member of the Rutgers On-Farm Food Safety Team, the New Jersey Food Safety Task Force, the Rutgers Vegetable Working Group, the NJAES Agritourism Working Group and Annie's Project NJ. She has a Bachelors Degree in Plant Science from Ferrum College and a Masters in Environmental Conservation Education from New York University.

Corrective actions – Actions taken to correct a problem and identify why it occurred in order to prevent it from happening again.

Cross-contamination – Contamination of one food item with microbial pathogens from another food item, water, surface, or other object.

Detergent – A cleaning agent that contains surfactants that reduce surface tension between food surfaces and dirt (soil) or other debris. Detergents aid in lifting dirt off of surfaces. Detergents are used in the cleaning process before a sanitizer.

Farm food safety plan – A written document that outlines the farm's food safety practices and may include record-keeping logs, Standard Operating Procedures (SOPs), and other supporting documents.

Food contact surfaces – The surfaces that contact human food and those surfaces from which drainage, or other transfer, into the food or onto surfaces that contact the food ordinarily occurs during the normal course of operations. This includes food contact surfaces of equipment and tools used during harvest, packing and holding.

Good Agricultural Practices (GAPs) – Any agricultural management practice or operational procedures that reduces microbial risks or prevents contamination of fruits and vegetables on the farm or in packing areas.

Microorganisms – Microorganisms means yeasts, molds, bacteria, viruses, protozoa, and microscopic parasites and includes species having public health significance. The term 'undesirable microorganisms' includes those microorganisms that are of public health significance, that subject food to decomposition, that indicate that food is contaminated with filth, or that otherwise may cause food to be adulterated.

No-harvest buffer zone – A defined distance around an identified risk from which produce should not be harvested. No-harvest buffer zones can be established around fecal contamination or around areas of significant animal intrusion to minimize the risk of harvesting produce that has been contaminated.

Postharvest water – Water that meets the definition of agricultural water and is used during and after harvest of produce.

Risk assessment – A process to identify potential hazards on a farm and/or in a packinghouse as well as the likelihood the hazards will impact the safety of fruits and vegetables.

Sanitize – To adequately treat cleaned surfaces by a process that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the produce or its safety for the consumer.

Sanitizer – A substance that reduces the amount of microorganisms to acceptable levels, typically for use on food contact surfaces. Sanitizers are generally considered to be part of a broader group of substances called antimicrobial pesticides. The antimicrobial product label will describe approved uses, such as for water or food contact surfaces, as well as approved concentrations or dosages.

Standard Operating Procedures (SOP) – Written description of an activity and how to properly complete the activity. An SOP should specify all the materials needed to complete the activity, the frequency with which the activity is conducted, and how to document the activity. An SOP may also include which employees are responsible for completing the activity and provide corrective actions to mitigate the problems that are likely to happen.

Traceability – The ability to track food produce through the food production and distribution system. In the case of fruits and vegetables, this includes back to the field where it was grown and any subsequent handling, storage, and sale.

Worker – Any person, paid or unpaid, working on a farm that grows or packs fresh fruits and vegetables. This includes growers, farm managers, family members, migrant labor, summer help, and packinghouse employees.

EDUCATING CONSUMERS AND MEDIA TO YOUR ADVANTAGE

There are many Extension based resources available to help farmers navigate food safety concepts, regulations and audits.

National Good Agricultural Practices Program, Cornell
https://gaps.cornell.edu/

Produce Safety Alliance, Cornell (FSMA Produce Safety Rule, Trainings by state)
https://producesafetyalliance.cornell.edu/

Produce Food Safety Program, University of California, Davis
http://ucfoodsafety.ucdavis.edu/Preharvest/

Rutgers Plant and Pest Advisory, Food Safety
http://plant-pest-advisory.rutgers.edu/category/commercial-ag-updates/food-safety/

KEEPING IN CONTACT WITH CONSUMERS THROUGH WEB-BASED MARKETING

Gillian Armstrong
Agricultural Project Management and Farm Marketing
gilliankarmstrong@gmail.com

Email marketing is one of the most cost-effective marketing channels for reaching a broad audience of customers who already show interest in your business. Creating a strong email strategy for your farm business can help to reach specific groups of customers in a personalized way to increase sales and brand awareness. This presentation will explore several email marketing services and tips that can help you create effective email campaigns. Learn how to create, customize, and measure your email campaigns to improve communication with your customers and drive sales all in one place.

Building a Successful Email Campaign

- Start with an objective
- Create a concise subject line
- Have a clean list/ Choose the right list
- Design your email to fit your brand
- Include a Call to Action
- Incorporate Social Pages
- Send & Measure.

With email marketing-- you have the power to generate revenue with the click of a button.

Gillian Armstrong is an Agricultural Program Coordinator and Research Assistant for Rutgers Cooperative Extension (RCE) of Middlesex County, New Jersey Agricultural Experiment Station (NJAES). Gillian concentrates on developing agricultural programming for RCE and assisting specialists in small fruit research.

She has received her B.S in Agricultural Sciences and Food Systems from Rutgers University, May 2015, with a dynamic academic career background. Ms. Armstrong has received awards and recognition for her premier leadership roles in numerous statewide agricultural organizations including, The New Jersey FFA Organization, Burlington County Board of Agriculture, and the New Jersey Farm Bureau Young Farmers and Ranchers program. She is well known by agricultural industry professionals for her leadership roles, and for her leading part in reestablishing the celebrated New Jersey Farm Bureau Young Farmers and Ranchers Program in 2013. Additionally, during her undergraduate career she worked closely with the New Jersey Department of Agriculture assisting on all levels in marketing the statewide campaign, "Jersey Fresh". Her hobbies include reading and writing, exercising, spending time at the beach, and working in agriculture. Gillian grew up raising, breeding, and showing dairy cows on her family farm in Columbus, New Jersey

BUILDING YOUR BRAND & IDENTITIY

Speakers: Will & Allie Johnson
Present for questions & answers also Jim & Wes Johnson
Johnson's Locust Hall Farm
2691 Monmouth Road, Jobstown NJ 08041
allie@johnsonslocusthallfarm.com

1. Who we are
    a. Johnson's Locust Hall Farm, 325 acre preserved farm with 8 acre exception area; 1787 stone barn, 1692 farm house, breezeway barn , market barn.
    b. Purchased this farm b/c families growing & many expressing farming futures saw opportunity in the Locust Hall.
    c. Sister farm of Johnson's Corner farm of Medford.
    d. Our location has been operational since fall 2014, opening with our fall 8 week pumpkin picking hayride season 2014.
    e. Locust Hall location opened following Johnson's Corner Farm's business plan & as we learned our area & customers we have and will keep adjusting to better fit Locust Hall farm.
    f. We offer: family u-pick entertainment operation, Gift Shop, CSA, Summer camp, Weddings & special occasion events, & Beef operation
2. Branding
    a. How do you create your identity?
        i. What sets your farm apart from all the others
    b. Logo
    c. Our brand & how it has affected our choices
        i. OUR BRAND IDENTITY = Highest quality of customer service, quality products, & beautiful historical farmstead, here is how we are profiting & expanding from our brand identity
            1. U-Pick operation & Farm market

Allie Johnson

EMPLOYMENT HISTORY

Sept. 2007-Present, Johnson's Farm, NJ

Manager, Events Coordinator

Position on family owned farm began customer service in children's birthday parties, working in the bakery, cashier, & visual merchandising. Promoted to manager fall 2014, & began overseeing new employees, customer service education, designing new 2nd farm location in Jobstown, buying, designing new market, planning & coordinating.

Married Will Johnson July 2016, roles within the business expanded to design consulting, overseeing growth of new business, & expanding farm departments. Focusing in the development of special occasion events on the farm, while emphasizing historical importance of the preserved farm. .

EDUCATION

Sept. 2010-Dec. 2012, Columbia College Chicago, BA

Received Bachelor of Arts Degree

Major academic course highlights: Art & Design, Entrepreneurship, Marketing, Computer Advertising, Graphic Design

Sept. 2009-July 2010, Burlington County Community College, AAS

2. Weddings & Special Occasion Events**(new)
    a. Our experience
3. CSA & Beef Operation **(new)
    a. Our experience

d. Staffing
    i. Help is an extension of your brand
    ii. Reward & Appreciate
    iii. Take time to teach & find everyone's best positions

3. Social Media
    a. Website
        i. Average of 3 seconds to capture your viewer
    b. Google
        i. Where do you list on google?
    c. Phone answering & messages
        i. Being accessible, call forwarding, returning messages
    d. Facebook
        i. Organic advertising vs. Monetary adverting
    e. Constant contact
        i. Update with events on the farm, projects in process make customers a part of your growth by getting them involved

William Johnson
EMPLOYMENT HISTORY
- Childhood through Highschool farm-hand for Johnson's Corner Farm
- Phl 17 Video Editor and Camera Operator May. 2013 – Nov. 2013
- Johnson's Locust Hall Farm 2014 – Current as Manger with focus on social media
EDUCATION
Sept. 2009 – June 2013, Rowan University, BA
- Radio, Television & Film
- Major academic course highlights: Film Production, Screen Writing, Media Law

4. Ideas we have tried/ try and fail, struggles
    a. Farm stand /roadside stand
        i. Our location far off the road, hard to get people up the 1500 ft driveway.
        ii. The competition is HIGH in our area
    b. PYO
        i. Summer & weekdays
            1. Getting customers to take a hayride
            2. Slow
    c. Cost of farming
    d. Staffing
        i. Finding good hardworking people to expand your brand
5. Summary
    a. Goal for our farm is to create memories & traditions. By doing so we become nostalgic & see many repeat customers.
    b. Be authentic!
    c. DETAILS MATTER

(From left to right: Jesse Barnard, Jim Johnson, Allie Johnson, Will Johnson, Pete Johnson, Brenda Johnson, Kaitlin Johnson, Wes Johnson)
Allie Johnson allie@johhnsonslocusthallfarm.com

PRACTICAL SAFETY CONSIDERATIONS WITH ON-FARM ACTIVITIES

William J Bamka, Agricultural Agent/Associate Professor
Rutgers Cooperative Extension of Burlington County
2 Academy Drive Westampton, NJ

All across the country, farmers are opening their doors to tourists and field trippers looking for an on farm experience. In New Jersey, more than 20 percent of farmers supplement their income through this practice which is helping more farms stay in business. The business of making farms travel destinations for educational and recreational purposes, commonly called agritourism, is an important type of alternative farm enterprise. It is an especially popular strategy among farms operating in proximity to urban/suburban areas in an effort to expand or diversify farm revenue, educate the non-farm public about agriculture, or expand traffic to existing farm retail outlets.

Production/wholesale farms are accustomed to dealing with and managing financial and production risks. However, agritourism activities bring additional legal, safety and financial risks that must be understood and managed. When developing agritourism activities safety planning is essential. The very nature of agritourism is to invite outsiders to your farm. Many of these individuals can be several generations removed from the farm and have no knowledge of farming practices and associated risks. The farm operator knows every rut and rill to avoid across the farm, but an outsider visiting the farm will not.

Identifying farm safety risks and developing a farm safety plan should be a priority when running an agritourism operation. A farm safety plan will help limit a guest's exposure to safety risks. As part of the safety plan operators are advised to inspect the farm regularly, walking through all areas that could be accessed by visitors (even those considered to be off-limits). Presented are some of the most prevalent farm hazards and potential risks encountered that could jeopardize the safety of guests and employees. Potential safety risks may be encountered in playground areas, corn/hay mazes, farm buildings used for public access, areas for farm animals and hay rides. It is also important to identify and secure areas of the farm that guests should be restricted from. As agritourism becomes more prevalent there are a growing number of resources available that can assist agritourism operators on developing their own safety plan.

As part of a NESARE-funded project the Rutgers Agritourism Team developed and delivered educational programming to agricultural educators and service providers interested in agritourism development. A key component of the training programming was to assist farmers in identifying and minimizing farm safety risks. Materials developed by the Rutgers Agritourism Team include videos, training modules, fact sheets and a series of checklists. The materials are useful to both established agritourism operations and operations newly in development. The resources are available online at http://agritourism.rutgers.edu/training/ .

Bill Bamka has been an Agricultural Agent and Associate Professor, since 1996, with Rutgers NJ Agricultural Experiment Station, Cooperative Extension. He serves as the South Jersey Regional Field and Forage Crop Agent. His major focus areas are in field and forage crops, nutrient management, alternative crops and marketing. Bill has expertise in farm safety and risk management for agricultural operations. He holds a B.S. degree in Agronomy from Delaware Valley College of Science and Agriculture and an M.S. degree in Agronomy from Penn State. He is also an NFPA certified Fire Fighter. He is a member of the Rutgers NJAES Agritourism Working Group. This group conducts education and research programs for farmers with on-farm direct marketing operations. He also helps lead the Rutgers NJAES Farm based beverage working group (RUBrew – Rutgers University Brewing, Research and Extension Work). He has a Bachelors Degree in Agronomy from Delaware Valley University and a Masters in Agronomy from Penn State.

ATHLETIC ACTIVITES ON AGRITOURISM FARMS

Michelle Infante-Casella, Agricultural Agent and Associate Professor
Rutgers NJAES Cooperative Extension, Gloucester County
1200 N. Delsea Dr., Bldg A, Suite 5, Clayton, NJ 08312

Agritourism has emerged as a profitable venture for on-farm direct marketing operations, especially in the Northeast where population centers are in close proximity to farms. This industry is ever-changing and offering service and hospitality opportunties to the public along with offering the traditional products grown on the farm. Over the past decade, utilizing the farm for activities that include forms of exercise and athletic events has become popular. Some of the most up-and-coming activities include variations of yoga, running events, some team sports and play areas for youth activity. Exercise has long been known to benefit the mind as well as the body. Also, well known are the relaxation benefits of being out in nature. Therefore, exercise and farm visits seem like a winning combination.

Before discussing some athletic and exercise activities that may be done on the farm, it is important to consider the business end of offering these events. As with any agritourism offering it is important to know local, state and federal regulations related to the activity. Additionally, making sure insurance policies will include the offered activities and cover the possible risks associated with these events is necessary to protect a business. Lastly, if a group is coming on the farm to host a sporting or exercise activity, they should provide the farmer an insurance rider to prove they have coverage. This places the burden of responsibility not just on the farmer, but also on the vendor for the activity. Once rules and regulations, liability protections and event management is planned the activities and fun can begin.

The health beneifits of yoga have been discussed in many circles. Yoga is a simple form of exercise that can be done just about anywhere. This allows for yoga to be done on the farm where there is an area large enough to accommodate a mat, an instructor and the students. One consideration is to make sure the yoga instructor is certified to teach yoga and that they themselves carry insurance. Although yoga seems like a benign activity, persons have been known to injure themselves and many states require instructors to be certified. Additionally, there are other complimentary offerings that can be coupled with the yoga class. Some creative yoga classes have incorporated goats, beer or wine to enjoy along with your "downward dog" position. The goal of yoga is to create a healthy mind and body in a relaxing setting. Many people perceive farms to be relaxing settings and enjoying their favorite alcoholic beverage while performing yoga moves seems to further relax some participants. Nevertheless, this activity has become quite popular in recent years and hosting yoga on farms has increased.

Running oppotunities, like 5K events, have also gained popularity just about everywhere. Runners are continually looking for new landscapes and challenges. So why not run on the farm? Picturesque venues like orchards, vineyards and wide open field spaces have all attracted groups of runners primarily for 5K runs or walks. Many events include a charity theme or a sesonal theme, where participants pay entry fees to run a set course on the farm. Often prizes are offered for winners and may just include a small medal or other prize for crossing the finish line first. Most participants just run for fun or to support the event's charity. As with every agritourism offering, preparation needs to take place for a successful and safe event. Making sure the course is free of debris, smooth, firm and well marked will make for runner safety. Knowing the plan for the race and if any obstacles will be added on the course by the event planners is important. Is it a mud run? Is it a color run? How many people are they registering for the event? Will the event planners need to make any alterations to the farm roads or fields? Make sure there are no surprises. Also, have a contract and know what is expected well in advance of the run. In most cases, hosting a running event on the farm

Michelle Infante-Casella has been an Agricultural Agent and Associate Professor, since 1996, with Rutgers NJ Agricultural Experiment Station, Cooperative Extension, in Gloucester County, NJ. She is responsible for vegetable production and marketing as well as field crops in Gloucester County. She is the chairperson of the Rutgers NJAES Agritourism Working Group. This group conducts education and research programs for farmers with on-farm direct marketing operations. Michelle is the NJ State Professional Development Program Coordinator for the U.S.D.A. Sustainable Agriculture Research and Education Program. She also serves on the National Association of County Agricultural Agents, Sustainable Agriculture National Committee. She has a Bachelors Degree in Horticulture from Delaware Valley University and a Masters in Plant Science from Virginia Tech. Originally from Monmouth County, NJ, Michelle and her husband Ben reside in Gloucester County, NJ and have two sons.

should not at all alter any areas of the farm and should not take tremendous efforts to plan or execute.

Hosting events on farm fields for athletics or excerise in production areas should not harm the production area for future use. One such alternate use for a farm field came about on a Southern New Jersey turf farm in recent years. Soccer is one of the largest youth team sports in the U.S. and in the world. Children now play soccer year-round and finding venues to host large tournaments can be challenging with regards to scheduling fields and parking. Soccer requires natural or synthetic turf and a flat surface. Where is natural turf readily found on flat surfaces? Turf farms have abundant acres of natural turf growing year-round. Therefore, hosting multiple soccer games for large tournaments could easily be done on a turf production field. Think about this, a standard youth soccer field is 100 yards long by 50 yards wide for a total of 15,000 square feet. An acre is 43,560 square feet. You could easily fit 2 soccer fields per acre with buffer spaces between each field. Hypothetically, on a 100 acre field of turf, that means 50 soccer fields could be errected for a soccer tournament with plenty of room inbetween. If the field is 200 acres, then there is plenty of space for close by parking, portable bathroom facilities and food vendors to service the event. Not every farm will have the ability to host soccer tournaments, but it has been done.

Although not an official athletic activity, youth play areas on farms has become a park-like attraction for some families. Having swings, slides, bounce areas, pedal tractors and carts, and other offerings has made agritourism farms family destinations. Be aware of all regualations, safety measures and employee management of these areas when adding them to the farm.

With each activity comes the chance of injury and lawsuits. Before implementing any new activity for an agritourism business, be sure to have all the details, protections and plans worked out to protect your business and to create positive experiences for your customers.

LINKING FOOD, FARMS, & TOURISM IN THE MID-ATLANTIC

Ginger S. Myers
University of Maryland Extension
Ag Marketing Specialist
Director, Maryland Rural Economic Development Center
gsmyer@umd.edu
301-432-2767

One of the cornerstone of any successful business is to know your product and know your target audience that wants or needs your product. Developing and agritourism enterprise on your farm it is important to remember that people are not coming to just purchase your vegetables or navigate your corn maze, but they are coming for an enjoyable and unique experience. Merriam Webster Collegiate Dictionary- "Agritourism is the practice of touring agricultural areas to see farms and often participate in farm activities". An Agritourism Business: 1. Recreates, 2. Educates or, 3. Facilitates sales.

Common attribute of agritourism enterprises include: 1. Produce food and/or fiber, 2. Produce new or unique products or experiences,3. Produce fun, recreation nature-based, or educational products.4. Can operate seasonally or year-round. States often have different definitions of agritourism for zoning, liability,or permitting purposes. Check your State's definition for regulatory restraints, permits, health requirements, and hours of operation.

Farm visits are rapidly becoming popular as a tourist destination. The U.S. Census of Agriculture clearly shows an increasing trend in agritourism and related recreational services.

Between the 2007 and 2012 censuses, 10,249 farms grossing $546-million in income increased to 13,334 farms grossing $674-million. Farms with gross farm receipts of $25,000 or more, increased from 3,637 farms to 4,518.

Specific types of activities also can be merged into a farm destination venue. For example:

Rural Weddings- Weddings are a $72 BILLION a year business. Average wedding costs $30K

Adventure Travelers- One-half of U.S. adults have taken an adventure trip in the past five years.

Camping-Number one outdoor vacation activity in the U.S.

Cultural or Historical Tourism- One in five of all U.S. person trips included a visit to an historical place or museum

So who is the target agritourism visitor and what attributes are they looking for during their visit? Here is a summary of a survey conducted in New York State profiling visitor characteristics and their preferences.

% of Customers Who Are Local to the Business's Home County or an Adjacent County

Winery……...15%

Festival……...61%

Farm tour……..78%

Corn Maze…….18%

Maple Operation…60%

Farm Stand…… 61%

U-Pick……53%

Ginger S. Myers is a Marketing Specialist with the University of Maryland Extension were she is the director of the Maryland Rural Enterprise Development Center. She formerly worked for the Howard County Economic Development Authority administering the county's Agricultural Marketing Program. Ms. Myers is a graduate of the Pennsylvania State University and serves on a wide variety of committees, including the Maryland State Agriculture Commission. She and her husband, John, operate a small farm near Westminster, Maryland. 2013

B & B……. 8%

Greenhouse……69%

Livestock……... 54%

"Other"……. 54%

Visitor Characteristics

Type of Group -

Most visitors went with friends and/or family.

Size of Group - Most groups contain 2-4 people.

Customer Age -

Largest segments:

Children under 12	32.3%
Adults 20-29	30.5%
Adults 40-59	23.6%

Visitor Preferences

What they enjoyed most:

1. Availability of family activities.
2. Setting and hospitality of the business.
3. Tasting food and/or wine.
4. Picking fresh fruits and vegetables

What was Important When Choosing an Attraction to Visit?

Friendliness of Staff	72%
Scenic Appearance of Farm	71%
Having Activities at the Business	58%
Presence of Farm Animals	33%
Presence of Barn or Other Historical Buildings	32%
Existence of a Gift Shop	16%

Agritourism activites can be economic drivers in their communities. They can provide upstream economic activities in the form of additional profit centers for land preservation parcels, maintains rural community development and expands the farm community's production base. Downstream economic activities include adds capacity for Tourism options, $$ for restaurants,hotels, service stations, creates jobs and stops leakage of tourism $$, and adds to the Quality of Life in the region.

When developing your plan for an agritourism enterprise on your farm first determine what is your "Attraction" and what will draw visitors to your farm. .Develop a Marketing Plan round your unique offerings, and review other issues such as insurance, labor and biosecurity, customer service and regulatory perimeters. Unfortunately, there is no tried and true formula for developing the perfect visitor experience and guarantee your business success. But, if in your planning and execution you emphasize creating a fun, enjoyable, entertaining, unique, and educational experience for your guest, you'll be off to a good start.

GLEANING TO FIGHT HUNGER AND REDUCE FOOD WASTE: THE ROLE OF THE FARMER

Brian Strumfels and Elyse Yerrapathruni
New Jersey Agricultural Society Farmers Against Hunger
1200 Florence Columbus Road, Bordentown, NJ 08505
fahvolunteer@gmail.com

Gleaning is the process of collecting surplus produce on farms as a means to fight hunger and reduce food waste. In the U.S., 1 in every 6 people experiences food insecurity, which means that they don't know where their next meal will come from. This includes 13 million children that do not get the nutrition they need to grow, learn, and focus in school. At the same time, experts estimate that more than 40% of the food grown, processed, and transported in the U.S. goes to waste. Nearly 16% of that waste occurs on farms, and another 13% is attributed to grocery stores and wholesale suppliers.

Many produce growers have surplus crops that cannot be used or sold, and therefore go to waste. There are many reasons for unsold produce, including but not limited to (1) buyer rejection due to surface blemishes, size / shape abnormalities, over-ripeness, (2) a drop in market pricing, (3) abrupt weather changes causing rapid ripening, and the lack of resources to harvest in a timely manner, and (4) dropped fruit that cannot be used. The surplus produce is either left in the field and plowed under, or, if already harvested, dumped in a landfill, where it contributes to greenhouse gases that damage our environment. While not harmful, the produce left in the field can be put to much better use feeding hungry people. But in the case of crops that are already harvested, keeping them out of the landfill is in everyone's best interest. In either case, donating unsold produce to a gleaning organization or hunger relief agency will help bridge the gap between food waste and hunger. Farmers Against Hunger (FAH), a program of the New Jersey Agricultural Society, is the largest and oldest gleaning organization in New Jersey addressing both issues of hunger and food waste.

Growers can either donate already harvested produce or support volunteer efforts to glean crops in the field. In NJ, Farmers Against Hunger partners with a network of more than 55 farms, and about half of the farms welcome gleaning volunteers. FAH works with many types of farms, including CSAs, U-Pick farms, farms with markets and roadside stands, wholesale farms and commercial farms. The program engages more than 1,200 volunteers each season from schools, corporations, service organizations, and a growing list of many individuals and families.

The gleaning season is one step behind the regular harvest season because gleaning is, by definition, collecting surplus produce after the main harvest. In NJ, the gleaning season typically starts in late June and goes through mid-December. Gleaning events are scheduled so as to be convenient for the farmers. Most farmers prefer that gleanings and/or direct pick-ups be scheduled on weekdays, especially on customer-driven farms. Towards the end of the season, some farms allow weekend gleanings. The average number of volunteers at any one gleaning varies depending on the day of the week, the time, the size of the farm, the crop availability, and the nature of the gleaning group. FAH has hosted gleaning events ranging from just 5 volunteers for a last-minute weekday to 50+ volunteers for a pre-arranged weekend day.

Brian Strumfels is the Program Director for the Farmers Against Hunger Program of the New Jersey Agricultural Society. He manages the produce distribution, teaches culinary skills, and helps to secure funding through grant writing. He graduated from Rutgers with a degree in fine arts. Wanting to serve the community on a full-time basis, he became a Bonner AmeriCorps volunteer with Farmers Against Hunger. At the end of the first farming season, he was hired part-time. In 2013, he became full-time, and in 2017, after nine years of rescuing and donating produce to people in need, he has stepped into a leadership position with the organization. Brian was raised in Hainesport, NJ and now lives close by with his wife and young daughter.

The farmer can be as involved or removed from the gleaning process as his/her schedule allows. Some farmers prefer that a staff-operated tractor and wagon accompany gleaners in the field, some enjoy providing a bit of background and history of the farm, and some simply give advance field directions to self-sufficient FAH staff. For most gleaning events, FAH staff (and sometimes volunteers) use trucks in the field to transport harvested produce to recipient agencies. If trucks cannot enter the field, volunteers can load containers on pallets that can later be moved by a tractor forklift, or farmers can join gleaners and load containers placed on a wagon.

Once loaded onto the FAH trucks, the gleaned produce is transported to hunger relief agencies and distributed to families and individuals in need. Often, produce goes directly from field to recipient organization, but some produce gets stored temporarily in a cooler depending on distribution routes and agency needs. FAH works with more than 75 community organizations across NJ, including pantries, soup kitchens and food banks. The program has a distinctive model of using food distribution sites – common meeting places for distribution to ten or more local agencies. This allows FAH to not only efficiently reach many organizations at once, but to also serve the smallest pantries and soup kitchens. The client demographics represent all races and ages, and both urban and rural locations in NJ.

The benefits of increased access to fresh produce for recipients are huge. But, there are also many benefits for farmers. Volunteers often become customers and support on-farm markets, roadside stands, and u-pick fields, thus contributing to a stronger local food economy, increased public awareness of agriculture, and long-term customer relationships. Farmers also benefit from the social connectivity to their communities – by donating produce, they have a direct impact on the issues of hunger and food waste. In addition, there are enhanced tax deductions for donations that some farmers can take at the federal level, and many states are also passing legislation to provide tax benefits to farmers that donate produce.

The 1996 Bill Emerson Good Samaritan Food Donation Act protects farmers from any liability related to donated produce. This law encourages food donations to nonprofit hunger relief agencies for distribution to individuals and families. FAH also has a required waiver explaining volunteer assumption of risk and release of liability and indemnity. The challenges of gleaning for farmers tend to be logistical – coordinating the ideal time for harvest, determining the best means of getting the produce out of the field, and temporarily storing gleaned produce on site if transportation and volunteer schedules to not align.

Elyse Yerrapathruni is the Director of Outreach and Events for the Farmers Against Hunger Program of the New Jersey Agricultural Society. She manages the gleaning program, teaches nutrition, and helps to secure funding through grants and fundraising events. She has her M.S. in Nutrition from The Pennsylvania State University. A native of Philadelphia, she now lives in NJ with her husband and three young sons.

CREATING A DIGITAL MARKETING KIT

Kim Rush Lynch

Agriculture Marketing Specialist, University of Maryland Extension, Prince George's County

A marketing kit reflecting your unique voice and style is an essential for tool for your business. Learn how to develop a compelling digital media package to attract your target market and grow on-line engagement. This session will cover the elements of a successful marketing kit and includes examples to help you develop an effective brand that resonates with your ideal customer.

Finding a Market Niche

Any farm business owner needs to think seriously about their market niche and what problem(s) their product and services may solve as well as what needs they meet. It is also important to understand what is unique about your farm business so you can explain how you differ from your competition.

Understanding Your Target Market

Once you have a clear picture of the benefits your farm business offers, as well as, how it stands out from the competition, it's time to pursue market research. Who is your target market? Consider demographics such as age, income level, occupation, gender, geographic location and education level. In addition, you want to consider psychographics such as special interest activities, philosophical beliefs, social factors, cultural involvements and other needs such as food and health requirements. This information will help inform where and how you will reach your customers and what kind of marketing collateral and tools will be most effective.

Elements of a Digital Marketing Kit

Why bother creating a marketing kit? It may seem like a lot of work but in the end it's a time saver! It gives you credibility, as well as, a recognizable, unique, professional and uniform brand. A marketing kit is an opportunity to deliver a clear and consistent message about you and your product. It serves as a tool to educate your clients about why they need your product, strengthen your relationships with them, and build new relationships and customers. It is important to consider the following elements in a digital format: logo, business card, farm profile and videos, website, social media, email marketing, product description and prices, recipes, testimonials, and incentives. You may also consider store demo offers, free food samples and other incentives as a part of your marketing kit. All of these pieces of collateral should be concise, reflect your style and image, and be in sync with the needs of your target market. Remember to make these pieces visual with professional graphics and video content. Hire a professional consultant to assist with design and photography. It's well worth the investment in the long run.

For over 20 years, Kim has been under the influence of food, from field to fork. This addiction has prompted her to participate in all aspects of the foods system - from growing food to nutrition and food education. As the Agriculture Marketing Specialist for Prince George's County, Kim works to keep current farmers on their land and attract new farmers to the County by connecting them with resources to either start-up or scale-up their enterprises. In addition, she helps farmers and farmers market managers navigate local regulations, while passionately promoting all things local food and farming in Prince George's County.

Kim serves on the Southern Maryland Agricultural Development Commission, Prince George's County Food Equity Council, and the Prince George's County Public School's Academy of Environmental Studies Advisory Committee. Kim has shared her expertise in food, farming and nutrition with organizations such as the Washington Youth Garden at the U.S. National Arboretum, Greenbelt Farmers Market, Greenbelt Co-op Supermarket & Pharmacy, Tulsi Holistic Living, and numerous corporations and non-profits through her health consulting business, Cultivating Heath. She graduated from St. Mary's College of Maryland with a B.A. in Biology.

When she's not thinking about food, you can find Kim in her garden, at her local farmers market, roller skating, or chasing her toddler, McKenna.

Social Media Best Practices

Social media, when done well, is a great tool for providing valuable content to gain the trust of your target market. According to the Pew Research Center, more than 50% of adult internet users are on two or more social media sites. Facebook still remains the most popular social media site overall, but shoppers social media platform of choice for finding products is Pinterest.

There are a variety of social media best practices including mixing up original and user-generated content applicable to your target market, posting visuals such as video, GIFs and infographics, adding your logo or website to images and infographics for easy sharing, being consistent with posting, using appropriate hashtags and handles wisely, responding to messages and comments in a timely manner, balancing promotion with educational content, and leveraging the power of complimentary high-profile accounts.

It's also important to develop a social media marketing and management plan. Select social media accounts that you enjoy and/or where you find your target market. It's better to develop one or two accounts well than multiple accounts poorly. Take time to create an editorial calendar of appropriate topics to post and consider what content is most compelling for your target audience. Develop content and incentives that will increase followership as well as drive people to your website and/or a call to action. It's important to evaluate your metrics to see what has been working and what needs tweaking. Finally, make use of phone apps such as Canva and Word Swag to assist you with punching up images and create compelling visual content. Be sure to take frequent pictures and video while in the field and save them future posts.

Be sure to peruse the social media accounts of competitors and complimentary services as well as industry publications. There are lots of nuggets of information to be gleaned.

Email Marketing Tips

The final component of any digital marketing kits is the e-newsletter. Newsletters allow you to deliver content right into someone's email box. Use a professional email service provider with beautiful templates and a database to help you track your readers. Examples include Constant Contact and MailChimp. When developing content, know your audience and select relevant material. Just as with social media, it's important to mix up your media and include podcasts, video, images, infographics, and GIFs. It is helpful to create an email marketing plan that includes a content calendar. Personalize your emails and thank you readers. Be as brief as possible and include teasers with "Read More" links (post longer articles on your blog). People are bombarded with email so it's important to develop catchy subject lines. Always include a "call to action" and include your social media links and website.

FARM APPROACH TO SOCIAL MEDIA

Kelly Jackson – Emily's Produce 2214 Church Creek Rd. Cambridge, MD 21613

During a time where farms are looking to diversify and employ strategies that will bring long lasting profits to the current and future generations, these agricultural entrepreneurs must remain vigilant in their efforts to market their businesses. With such a large percentage of the public who now uses social media to remain in touch with their favorite business or familiar face (PEW Research Center reports 70%), farm related businesses need to realize the impact that social media can have on their "bottom line" and reputation. To completely understand the impact that social media could have on your farm related business, you need to first become aware of the most popular platforms to date.

Facebook –
According to Business News Daily, Facebook is the biggest social media network on the web, both in terms of recognition and number of users. With nearly 2 billion active users, Facebook is a great medium for connecting people from all over the world with your business. Facebook allows you to share important updates, events, photos, videos, and it has the capability to link to websites and other web-based platforms like newsletter programs.

Twitter –
Twitter allows users to share short text updates (140 characters or fewer), along with videos, links, images, and more. "Tweets" can be easily linked to other users by using hashtags and "re-tweeting" other content. Those who prefer to use Twitter as one of their primary choices for social media engagement must remain cognizant of how they can appear well rounded and not focus solely on content from the user's own business. Remember – this is "social media"!

Instagram –
Instagram consists of a visual platform that uses photos and videos to engage the public in a mobile capacity. This social media tool is intended to be used from mobile devices and has the capability to enhance and edit photos and videos with unique filters and tools.

YouTube –
YouTube is a video-sharing platform with over a billion users, where people can view, upload, rate, share and comment on content. Now owned by Google, the site is a huge hub for news and entertainment. Many businesses on YouTube have a creative, visual or educational component. The platform is heavily driven by creativity in nature, so it's important to have a tailored video editor producing content.

Pinterest –
Pinterest is a visually oriented platform that allows users to save and display content by "pinning" digital bulletin boards, which can be organized by category. For example, a personal user might have a food board dedicated to pinning recipes, another board dedicated to photography, and so on. The platform also has a series of special types of pins called Rich Pins, which brands can use to add special information to their pins, like product details and even location maps.

Kelly Jackson and her husband Paul Jackson own and operate Emily's Produce in Cambridge, MD. They along with their two children (who are the family's 7th generation of farmers) maintain a reliable agricultural presence in the community. The business offers u-pick, a CSA program, an on farm kitchen that produces baked goods, value added products, lunch and breakfast, and fruits, vegetables, and meats that come from the family's own farm. Kelly Jackson is a retired Maryland State Police Captain with 23 years of service who has been recognized for a variety of business awards in her community and beyond.

Every pin includes an image or video, and like Facebook, it is fairly low-maintenance in terms of post frequency. However, keeping your boards organized and search-friendly can be time-consuming. It's also more of a niche network than Facebook or Twitter, so it may not work for everyone. Popular categories on the site are DIY projects, fashion, exercise, beauty, photography and food. That's not to say that businesses outside of these categories can't succeed on the platform, but it does make Pinterest an especially good marketing tool for businesses in those areas.

Snapchat –

Snapchat is another mobile-only visual social media network (like Instagram) that's known for its disappearing content. The 150 million-plus app users can send videos and photos, available for up to 10 seconds at a time, to one another, or post content to their public Stories, which disappears after 24 hours.

Because posts are so temporary, there is less pressure to create super-polished content. You can also see how many and which specific users viewed your story. A small business will mostly likely utilize the platform for its Stories, but keep in mind that only users who have added you can view the story content. However, once you have an audience, the story feature allows you to easily create story-driven and interactive content.

SOCIAL MEDIA MARKETING FOR GREEN/AG/HORT BUSINESS

Kathy Jentz, Washington Gardener Magazine

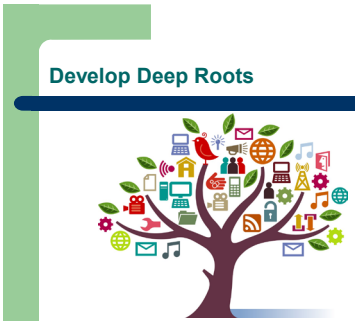
Slide 1

Slide 2

Slide 3

Slide 4

Slide 5



Slide 6

Social Media Basics

- Short, Easy Name
- Use YOUR Photo
- Same Identity across Your Social Media
- Connect Your Social Media Accounts

Slide 7

To Be Followed, Follow Back

- The key word in Social Media is SOCIAL
- Start off following more people than follow you back

Slide 8

Social Media No-Nos

- All About ME ME ME
- Never ReTweeting or Giving Credit
- Not Responding
- Sounding Like a Broken Record (but you do want to repeat sometimes)
- Not Tweeting/Posting Regularly
- Not Showing Your Personality

Slide 9

Challenges of Social Media

- Cutting through the Clutter
- Time-Suck
- Connecting to Followers

Slide 10

Hashtag Basics

A hashtag is the indexing tool for social media.

Think of it as a KEYWORD search

Slide 11

Why use hashtags?

Help people find YOU in the big (and growing bigger every day) social media world!

Create a community participate in live events be "in the know" create a personal brand find out news researching story ideas

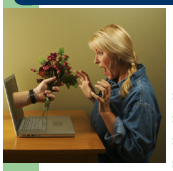
Slide 12

WARNING! WARNING! WARNING!

- Hashtags are #Addictive
- #nokidding
- #whocares
- #preachonsister
- #speakthattruth
- #gettotheprogramalready

Slide 13

Hashtag can be confusing…



Hashtag are ALSO used as humor, sarcasm, memes, or commentary.
#youhadonejob
#ruinachildrensbook
#sharknado
#yesallwomen

You cannot control or copyright a tag humor is fun – use it!

Slide 14

Where to use hashtags?

- Twitter
- Facebook
- Google+
- Instagram

Slide 15

Common HORT Hashtags

- #Gardening
- #Garden
- #UrbanAg
- #SchoolGardens
- #PublicGardens
- #Green
- #Plant
- #Flower
- #Tree
- #Seeds
- #Bloom
- #Edibles
- #Veggies
- #Gardentours
- #Bulbs
- #Natives

This is the tip of the iceberg!

Slide 16

Other Hashtags to Use

- Use colors #purple
- Use locations #WDC #DC #MidAtlantic
- Use seasons #spring #Christmas
- Use feelings #happy
- Use adjectives #yummy
- Use specific plants #daisy #salvia
- Use related interests #foodies #wildlife
- Use to instruct and inspire #plantthis #youcangrowthat
- Use people you want to reach #bloggers #chefs
- Use for events #MAFVC18
- Use for live chats #rosechat

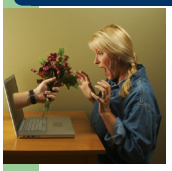
Go to my photos and practice some tagging

Slide 17

Hashtag this!

Slide 18

Make Your Own Hashtags



- #GardenDC
- #SeedSwapDay
- #GardentipoftheDay

NOTE:
~ No one owns a hashtag!
~ Check if others are using it
~ Be careful about misreadings
#greenroofsuk #greenroofuk

Be careful how the tag can be possibly misread make sure it is not being used for other purposes

Slide 19

Hashtag Dos and Don'ts

- No spaces in a hashtag
- No period or punctuation
- Use at end but can also be used in the middle of a post – never at start, if you want to share the post on Facebook

Wrong Examples: "#MAFVC18 rocks!" "I love # MAFVC18!"
Correct Example: "You all missed out # MAFVC18 rocks #landscapedesigners are the coolest people. #youwishyouwerehere"

Slide 20

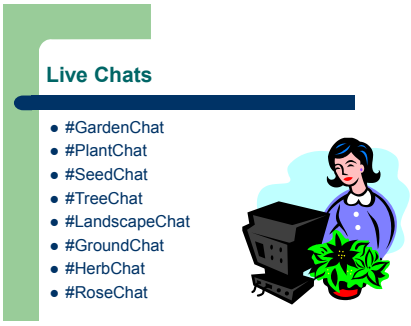
Hashtag Example – Twitter/Facebook

Saw these cool origami newspaper pots at #phillyflowershow #gardening

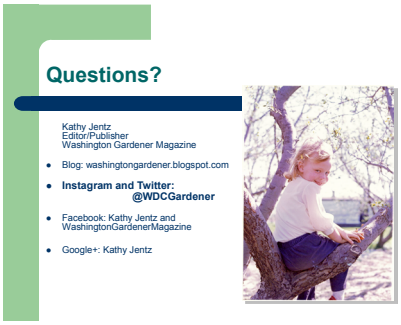
Slide 21

Slide 22

Slide 23



Slide 24



I am available for hire as a social media coach and I also do social media ghostwriting for small garden companies and individuals

Save time, save money, save the planet.

This is the "Bio360 Biodegradable & Compostable Mulch Film".

"Bio360 Biodegradable and Compostable Mulch Film" made of Mater-Bi, completely disappears without a trace and without leaving any toxic residue. It also saves both time and money because you don't have to remove it. What's more, you'll be helping the planet. It also promotes rapid root growth and eliminates weeds. So it's a win-win situation! Ask one of our representatives how much you can save using this revolutionary new product.

Nolt's Produce Supplies
717-656-9764 - Leola, PA
noltsproducesupplies.net

For other regions, contact US
1-844-4BIO360 (1-844-424-6360)

EXPERIENCE 15 YEARS SUCCESS MOH-MONY

BIO 360
Biodegradable | Compostable Mulch Film

VOTE YES

PENNSYLVANIA
Vegetable Marketing
& Research Program
WWW.PAVEGGIES.ORG

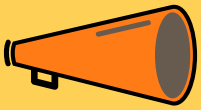
WHAT DOES YOUR VOTE SUPPORT?

PRACTICAL RESEARCH

$620 THOUSAND devoted to vegetable research since 1988

350 projects funded in last 30 years

EFFECTIVE MARKETING



60 media sources published and shared PA Produce Month news

over 2 million impressions from 2017 press activity

28,000+ people saw PA Veggies Facebook content in 2017

"Vegetable growers of all sizes benefit from the research coming out of these programs, so it is important that we also contribute accordingly to ensure the continued success of the PVMRP and our industry as a whole." - PA Farmer

FARMER RESOURCES

DOZENS OF FREE RESOURCES

- SHAREABLE CONTENT
- GENERAL TIPS & IDEAS
- MARKETING CALENDAR

PVMRP is a statewide marketing order established by a grower referendum. governed by a grower board, and funded by grower assessments.

717.694.3596 WWW.PAVEGGIES.ORG