
MID-ATLANTIC
Fruit & Vegetable Convention
2025
Proceedings

Mark Your Calendar!

2026 Mid-Atlantic Fruit and Vegetable Convention

Proceedings

for vegetable, potato, small fruit, and other sessions

MAFVC Sponsored by
State Horticultural Association of Pennsylvania
Pennsylvania Vegetable Growers Association
Maryland State Horticultural Society
New Jersey State Horticultural Society and
Virginia State Horticultural Society

In cooperation with
Penn State Extension
Rutgers Cooperative Extension
University of Maryland Extension
Virginia Cooperative Extension

Proceedings published by
Pennsylvania Vegetable Growers Association
908 N 2nd St | Harrisburg, PA 17102
717-973-5915 | www.pvga.org

Pennsylvania Vegetable Growers Association

An association of vegetable, potato, and berry growers

Board of Directors

President | Peter Flynn
First Vice President | Tina Forry
Second Vice President | Morgan Bond
Secretary-Treasurer | William Reynolds
Past President | Rita Resick

Board Members:

Brian Campbell • Christopher Harner • Barron Hetherington • Alan Kemmerer
Arthur King • Amy Metrick • Laverne Nolt • James Reiff • John Shenk
Robert Shenot • Jeffrey Stoltzfus • Jonathan Strite • Mark Troyer

Staff

Executive Director | Tammy K Linn
Convention & Registration Coordinator | Jason Tobias
Project Assistant | Mia Murray
Accounting | Michele Dibble

PVGA Convention Task Force

General Chair – Tina Forry
Program Chairs – Agritourism – Claudia Schmidt • Cut Flowers – Glen Bupp, Margaret Pickoff
Drones & AI – Peter Flynn, Leah Fronk • Food Banking – Rob Amsterdam
General Vegetables – Jeff Stoltzfus, Tim Elkner • Green Beans – Leah Fronk
Greenhouse – Floriculture – Krystal Snyder Greenhouse – Vegetables – Krystal Snyder, Francesco Di Gioia
High Tunnel – Francesco Di Gioia Hydroponic – Francesco Di Gioia
Labor/Farm Management – Linda Falcone • Leah Fronk, Peter Fynn Marketing – Brian Moyer
Marketing – Carla Snyder • Marketing – William Hlubik
Marketing Technology and Tools – Sarah Cornelisse, Shannon Dill, Veronica Yurchak
Microgreens – Francesco Di Gioia • Peppers/Eggplant – Leah Fronk Tim Elkner • Potatoes – Rob Leiby
Sweet Corn – Chris Harner • Pumpkins – Tom Butzler, Tim Elkner • Retail Marketing – Miranda Harple
Root Crops – Glen Bupp, Art King • Small Fruit – Kathy Demchak, Patricia Prade & Haley Sater
Soil Health – Francesco DiGioia • Tomatoes – Ken Martin • Vine Crops – William Reynolds

Additional Task Force Members

Steven Bogash, Will Brownback, Michael Orzolek, Don Seifrit, Daniel Weber

Audio-Visual Coordinators

Thomas Butzler, Robert Pollock, Donald Seifrit, Daniel Weber

Table of Contents

Continued on next page

Table of Contents

Potatoes (continued)

Pumpkins

Root Crops

Small Fruit

Soil Health

Sweet Corn

Tomatoes

Vine Crops

'Remembering Bill Lamont'

Getting Scrappy with Marketing and Season Extension

Katie And Margie Dagnal
Goose Creek Gardens. Ltd.
229 Rest Home Road | Crownsville, PA 16218
hello@goosecreekgardens.com

Marketing was so much easier before social media, or was it? Before social media you spent money with the local newspaper and hoped you would get new customers. Today everyone has a phone in their hand, and this is how they decide to start following you or not. If you don't have access to computers or cell phones – please keep reading.

There are three main platforms: Instagram; Facebook; X(formerly Twitter). All can be very, very beneficial to your bottom line. Depending on your location and how you sell your product will decide which platform is the best for you. Instagram is great to catch the attention of the 45 and under age group and as we say national customers. Facebook is the one to use for local customers of all ages. We focus our marketing efforts on Instagram and Facebook for our farm.

Now you have followers on any or all platforms, what do you do? You work to get their email address and create your own mailing list.

Why do you need to have your own email list. The easy answer is: you do not own any of the content you put on your social media accounts. You own your email list. If social media went away or you get locked out of your account for some reason, it can happen and often does when we need to communicate with our customers. How are you going to reach them? How will they know you have an abundance of a certain product that week or that your times have changed unexpectedly for your farm stand? With your email list you can easily communicate with your customers any time you need to.

The email/mailing list is your best way to get directly to your customer.

You want to stay in contact with them even when you have nothing to sell.

Margie and Kate Dagnal, *Mother & Daughter. We have been growing for over 20 years, the last ten have growing flowers exclusively. We have sold via many avenues, direct to consumer, CSA, and wholesale. We now sell wholesale locally and retail via shipping across the country. We are a year-round farm; we provide cut flowers March through November.*

We did this for over 10 years before we asked our customers to buy from us. We sold wholesale, and we moved over 50 miles from where we had done famers markets for 10+ years. We had to create a who new customer base if we ever wanted to do direct sales locally but also wanted to keep in touch with our old customers.

The key is to be consistent with contacting your subscribers. We do a weekly email newsletter about what's going on here on our farm. Our newsletter is only a few paragraphs with several photos of the farm and our product. What we have found is that we as humans are very nosey. We want to know who you are, and can we trust you before we purchase. People love the behind-the-scenes photos and little tips and tricks of what you do day in and day out. To us it might not seem that fascinating because it is our life, business, or farm. However, by sharing this information to our email subscribers or followers on social they get to learn about you and trust

Continued on next page

Getting Scrappy with Marketing and Season Extension (continued)

your business. Everyone has a story, and it is worth telling!

You can do a once-a-month newsletter letting them know what's going on. Maybe you are tapping your maples for syrup, ordering seeds, starting your seedlings, repairing equipment, or your opening day and what you will have. You do not ever have to share anything you don't want to. We have been very specific about who and what are in our newsletters. We rarely show our children/grandchildren, and we respect our employees and do not show them without their approval. We keep it business related telling them about what crops we just planted, how the weather was that week, our latest blog with a link back to our website, featured products for our online customers, and what will be available at our self-serve farm stand "The Flower Shack" that week with the hours.

How do you get these email addresses? You ask for them! If you do not have a website and you do have social media, ask them to direct message you with this information. If you only have the option of mail create a mailing list at your market and ask people to sign up. Then send out a beginning of the season brochure with what you will have in the upcoming season. Also include where and when your customers can find your great products. A tip for in-person markets, put a couple fake names and addresses at the top of your list. No one ever wants to be the first to sign up.

You do not ever have to share anything you don't want to. We have been very specific about who and what are in our newsletters. We rarely show our children/grandchildren, and we respect our employees and do not show them without their approval.

When you send your newsletter, and you see how many people you are sending it to think in terms of that person came and visited your store.

This does take time to do this, and time is money! It is very worth it. It might seem scary or intimidating at first to share your story about your business, but people want to know, and they will listen.

Now is a great time to plan your strategy for your opening day!

Remember, if it was easy, everyone would do it!

Did you ever want a hoop house and felt it was out of your reach?

We felt we needed a hoop house early on and we bought one for $800, 20 years ago. We loved it! Extending our season in the spring as well as in the fall is important to a small farm.

We were fortunate to attend a seminar at a college that had a large CSA and we toured their greenhouse and hoop houses. The farm manager stressed that you need to look around your farm and use material you have on hand to help grow a better crop or more crops.

We went home and we took a hard look at our commercial hoop house. We knew that we could come up with a design that fit our needs using the material that we had on hand or that was readily available in our area. That's just what we did, and our hoop house design has benefited our farm for many years.

The design we came up with used rebar for the hoops in plastic pipe.

Our house is 12' wide, 40' long and 7' high in the center. We have been growing in these for over 20 years. They have been moved, gone through wind, floods, and snowstorms and still stand.

Getting Scrappy with Marketing and Season Extension (continued from page 6)

Don't get me wrong, a microburst can still take it out. The fact they are only 7' tall heavy snow can be removed more easily.

These are not pretty; our carpentry skills are rudimentary at best. They can be built much longer than ours, but we find that 40' is right for our production. We place the ends east to west for passive air flow and keep the ends open during the summer months.

We have grown culinary herbs; salad greens and other edible greens; cut flowers and we do use one for a chicken coop. Other crops that high tunnels are used for are raspberries; tomatoes; and peppers. High tunnels give your crop protection from wind and rain damage. Our first high tunnels protected our crops from small animals.

For the early growing season, we grew cool season crops and have always had a saleable crop the first of April. We also grew cool season crops in fall that have added a few weeks to many weeks of production during the fall season.

Examples: Brassicas and root crops make it until the end of the year. More tender items make a few weeks past the first frost. Additional weeks can add to much needed revenue.

Cut flower production in these high tunnels has been successful as well. We have successfully grown anemones, ranunculus, snapdragons, dianthus, tulips, scabiosa, marigold, heirloom chrysanthemums, and many other cool hardy cut flowers.

The benefit of these hoop houses for our farm is that they aren't too big to maintain. We have larger commercial high tunnels that are great, but we find these smaller houses perfect for really focusing one to three crops per hoop house. We find this beneficial when it comes to disease and pests. In our smaller hoop houses if there is a problem with disease or pest it can be contained to just the one to three crops and not spread. Whereas in our large commercial high tunnels more crops are at risk of disease or pests, if not caught early they can spread though out the high tunnel quickly. Another benefit of our smaller hoop house is it is easily maintained by one or two people. We can quickly go into the hoop house and in a day flip it from an old crop to a new crop. For a small team like ours that is a win in my book!

These houses can be made to look professional, or as we do, just functional. The current cost of the new materials for construction is less than $500.

The only tools required are tape measure, saw and drill.

For a free PDF with the basic instructions and material list. Please send a note with a request for PVGA25 and email: hello@goosecreekgardens.com

Happy Growing!

Short Form Video Trends and Social Media Algorithms

Maureen Ballatori | Founder + CEO
Agency 29
127 Railroad Street, Suite #220 | Rochester, NY 14609
maureen@agency29.com

Summary

In the evolving landscape of social media, video content has become a powerful tool for brands to engage audiences and build loyalty. Brands must focus on creating content that compels viewers through emotional reactions, educational value, and entertainment. The most effective video strategies encompass five key approaches: entertaining videos that spark curiosity and connection; educational content that establishes expertise; authentic behind-the-scenes glimpses that humanize the brand; user-generated content that provides social proof; and interactive contests or challenges that generate excitement and viral potential.

Different social media platforms have unique algorithm preferences, but they share common principles. Facebook prioritizes variety and user interaction, recommending vertical videos with creative tools and engaging content. Instagram favors Reels that are entertaining and use innovative features, while TikTok bases recommendations on user interactions and trending elements. YouTube's algorithm focuses on viewer history, engagement signals, and content relevance.

The path to successful video marketing isn't about discovering a secret formula for going viral, but rather implementing consistent strategies. This includes using trending sounds, creating similar-style content, following and initiating trends, and practicing social listening.

By understanding platform-specific nuances and focusing on genuine audience connection, brands can create video content that not only reaches viewers but also builds meaningful engagement and brand loyalty.

The ultimate goal is to craft video content that emotionally resonates with audiences, providing value through entertainment, education, or authentic storytelling. Continuous analytics monitoring and a willingness to experiment with different approaches will help brands refine their video marketing strategy and effectively connect with their target audience.

Maureen Ballatori *(she/her) is the founder and CEO of Agency 29, an award-winning creative agency for food, beverage, and agriculture brands. Her experience in brand strategy helps companies scale business growth, define their unique marketing message, and attract their ideal audiences. Maureen's rural roots are the source of her passion for agriculture marketing and food. She grew up on a dairy farm in Upstate NY. An active community member, Maureen holds multiple board seats for local and international organizations, and she is a national speaker and workshop facilitator.*

The path to successful video marketing isn't about discovering a secret formula for going viral, but rather implementing consistent strategies.

Short Form Video Trends and Social Media Algorithms (continued from page 8)

Core Objectives

- Prioritize engagement
- Compel audience through:
  - Emotional reactions
  - Attention-holding content
  - Educational value
  - Entertainment

Types of Effective Video Content

1. **Entertaining Videos**
   - Designed to evoke emotions and spark curiosity
   - High viral potential
   - Encourages audience interaction
   - Creates strong brand connection
2. **Educational Videos**
   - Positions brand as an industry authority
   - Demonstrates knowledge and awareness
   - Builds trust and credibility
   - Covers tutorials, how-to guides, and insights
3. **Authentic Behind-the-Scenes Content**
   - Humanizes your brand
   - Creates transparency
   - Builds audience trust
   - Shows real people and processes
4. **User Generated Content (UGC)**
   - Provides social proof
   - Increases brand engagement
   - Builds trust through peer recommendations
   - Statistic: UGC ads get 4X more click-throughs
5. **Contests and Challenges**
   - Creates excitement and anticipation
   - Potential to go viral
   - High shareability (94.46% of participants share immediately)
   - Amplifies brand exposure

Platform-Specific Algorithm Insights

Facebook

- Prioritizes variety in post types
- Recommendations:
  - Vertical video
  - Good lighting
  - Built-in creative tools
  - Original content
  - Average user watches 26 min/day

Instagram

- Prioritizes Reels
- Favors:
  - Entertaining content
  - Creative tools
  - Original, high-resolution videos

TikTok

- Recommendations based on user interactions
- Considers:
  - Captions
  - Sounds
  - Hashtags
  - Trending topics

YouTube

- 70% of recommendations driven by algorithm
- Considers:
  - Past viewing history
  - Engagement signals
  - Content relevance
  - Channel authority

Going Viral: Key Strategies

- Use trending sounds
- Consistency in content
- Follow and create trends
- Practice social listening

Final Takeaways

Leverage video content to emotionally engage audiences, build engagement, and deepen brand loyalty and continuously monitor analytics to understand what works best for your brand.

Selling Product to Pennsylvania Food Banks

Tom Mainzer | Director of Agricultural Partnerships
Feeding Pennsylvania
20 Erford Road, Suite 115 | Lemoyne, PA 17043
tmainzer@feedingpa.org | 717-257-9850

Summary

Pennsylvania is home to more than 52,000 farms covering 7.3 million acres, yet more than 1.5 million Pennsylvanians face hunger. With this abundance of resources, no Pennsylvanian should go hungry. Agricultural partnerships allow Pennsylvania's farms and families to thrive.

Designed to support PA's agricultural producers in weathering the whims of mother nature and market pressures, the Pennsylvania Agricultural Surplus System (PASS) pays producers for wholesome food products. Instead of being left in the fields or landfilled, food is diverted to Pennsylvania's food banks.

The USDA Local Food Purchase Assistance Cooperative Agreement Program (LFPA) provides funding for state, tribal and territorial governments to purchase foods produced within the state to help support local, regional, and underserved producers. While increasing local food consumption, the funds help build and expand economic opportunities for local producers.

> Pennsylvania is home to more than 52,000 farms covering 7.3 million acres, yet more than 1.5 million Pennsylvanians face hunger.

Produce Planning

Growers interested in participating can work with their regional food bank to plan for needed products for the upcoming season. As supply is available for the food bank, it can then be purchased using PASS/LFPA dollars to be distributed locally in your area.

***Tom Mainzer** serves as Director of Agricultural Partnerships for Feeding Pennsylvania. In that role, Tom is responsible for developing agriculture programs and relationships, as well as managing the Pennsylvania Agricultural Surplus System, USDA Local Food Purchase Assistance, and USDA Farm to Food Bank programs. He works with agricultural producers and food manufacturers on opportunities to support Pennsylvania's charitable food system all while helping to reduce hunger and food waste within the Commonwealth.*

Producer/Vendor Networking

Don't have time to connect with your local food pantries? Feeding PA will help you connect to a network of food banks and their agency partners, saving time and making it easier for you to move your products into the charitable food system for the greatest impact and financial return.

Surplus Food Products

Have surplus products? We'll work with you to divert your wholesome, fresh produce to families who need it most, and you'll be paid a fair price for your products.

Expanding Markets for Pennsylvania Producers

Our programs are designed to create new market opportunities for vendors of all sizes throughout Pennsylvania. We help connect smaller farms and growers to local food pantries where they can arrange delivery or pick-up of food products to support families in the local community.

Asparagus Disease

Mary Hausbeck | Professor and Extension Specialist
Michigan State University
140 Plant Biology Lab | East Lansing, MI 48824
Hausbec1@msu.edu

Unlike annual crops where an epidemic in one year will not necessarily influence yields in subsequent years, premature defoliation of the asparagus fern from a plant pathogen may reduce plant vigor. Consecutive years of premature defoliation have been shown to critically reduce subsequent yields. The primary pests of asparagus include both foliar and soilborne pathogens that are currently managed in seedbed and production sites using fungicides. The goal of our field research has been to develop and test new tools and strategies for managing diseases in asparagus.

***Mary Hausbeck** is a University Distinguished Professor and Extension Specialist at Michigan State University where she focuses on pathogen detection and disease management of vegetable crops and greenhouse flower and ornamental plants. She received her PhD in plant pathology at Penn State. Her research and extension program has supported and trained many students.*

Foliar Diseases. Fungicides are applied to asparagus fern that develop following spear harvest to manage rust and purple spot, which are the most important foliar fungal diseases of asparagus in Michigan. Purple spot (caused by Stemphylium vesicarium) occurs on both fern and the edible spears. Purple spot lesions may result in spears being rejected for the fresh market. Rust (caused by Puccinia asparagi) only affects the fern. Both rust and purple spot can develop on the main stem, secondary branches, and cladophylls and can be present together increasing defoliation. Premature defoliation decreases carbohydrate stores in the crown, which can limit yield in subsequent years and cause plant stress that may increase susceptibility to soilborne pathogens such as Fusarium.

Rust disease of asparagus is a problem on fern following harvest of spears. The rust fungus produces several types of spores that can result in infection. Basidiospores develop in very early spring on the overwintering asparagus debris which harbors teliospores from the previous fall. When the basidiospores infect asparagus fern, the resulting lesions are oval and light orange. The lesions turn a bright orange color due to the production of aeciospores. Signs of rust do not occur on harvested spears. Aeciospores are an early source of inoculum for rust epidemics and are typically first seen on volunteer asparagus and on plants in young beds that are not harvested. Air currents and splashing rains carry the orange aeciospores from the lesions to other branches and needles (cladophylls) where they germinate and cause new infections when free moisture is present.

The aecial stage of rust is the first sign of disease. The next stage of the rust life cycle that occurs is the repeating or uredial stage, which is responsible for the epidemic phase of this disease. Urediospores are produced in great numbers and may resemble a reddish dust. They germinate in the presence of moisture and within 10-14 days may cause infections and yield a new generation of spores. Therefore, a relatively small number of uredia can reproduce rapidly to cause significant and damaging levels of disease. Uredial lesions occur in mid- to late-

Continued on next page

Asparagus Disease (continued from page 11)

Using slow-rusting varieties, removing volunteer plants, scouting fields and applying fungicides early in the season before rust becomes established is a sound management practice. Timing the start of a spray program at the first sign of the disease, identified by scouting, may be helpful.

summer. The final stage occurs in late summer with production of the black teliospores, which overwinter in plant debris. The fungus causing rust can attack all aboveground parts, and severe infections can stunt or kill young shoots, and can defoliate plants. Damage is most severe when fern is attacked several years in succession. During spear harvest asparagus plants deplete stored carbohydrates which are replenished during fern growth. If the fern becomes infected by rust, it may turn yellow, then die early in the summer, thereby reducing the time needed for replenishing the reserves in the crown. Research studies indicate that the disease can have an additive negative impact over time on yield. For instance, yield losses ranged from 2-23% (depending on the cultivar) after one year of rust infection. However, after two years of consecutive infection, yield losses increased and ranged from 11-54%. Since rust can reduce the yield and longevity of an asparagus field, disease management is needed. Resistance to rust in some asparagus varieties has been identified and found to reduce the intensity of rust infection. Hence, varieties with this type of resistance are called “slow rusting” and are used by most growers. However, even slow-rusting varieties can become severely diseased. Interrupting the aeciospore stage in the early spring prevents development of the repeating urediospore stage and dramatically decreases the risk of an epidemic and need for fungicide sprays later in the season. Using slow-rusting varieties, removing volunteer plants, scouting fields and applying fungicides early in the season before rust becomes established is a sound management practice. Timing the start of a spray program at the first sign of the disease, identified by scouting, may be helpful.

Purple spot survives the winter as sexual spores (ascospores) in a sac (ascus) produced in overwintering structures (pseudothecia) that appear as small black dots on asparagus debris from the previous season. The ascospores are released from the ascus by rain and can be carried by the wind to newly emerged asparagus plants, where they cause the primary infection of the growing season. These new infections result in spores (conidia) produced by an asexual process, which in turn can cause secondary infections, a process that is repeated if temperatures and rainfall are favorable. The emergence of purple spot as a significant problem in the production of asparagus in Michigan may be due to the adoption of a no-till cultural system, whereby the dried fern from the previous season is chopped in April and left on the soil surface. This residue persists through the harvest season (mid-June) and is visible through the fern growth period (late June to September) and is the source of ascospores which start infections early in the growing season. The disease appears as numerous, slightly sunken, purplish spots with brown centers occurring on harvested spears and fern. Lesions on spears are often found on the windward side, because blowing sand causes wounding which favors infection. During epidemic years spotting can

Continued on page 14

Things I Wish I Knew When I Started

Peter Flynn
Pete's Produce

This talk is in a panel format and audience participation is expected. This is an outline of the discussion, but we will follow the input of the attendee's.

1. Your Idea Isn't Enough

A great idea is just the beginning. Success requires execution, persistence, and adaptability. Test your idea in the market to ensure there's demand.

2. Cash Flow Is King

Many businesses fail because they run out of money, not because they aren't profitable. Understand your cash flow and always keep a financial cushion.

3. Know Your Customer

Understanding your target audience is crucial. Invest time in market research to identify your customers' needs, preferences, and pain points.

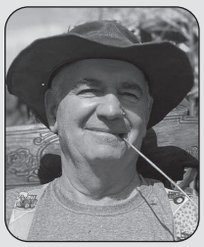
4. Don't Overcomplicate Your Offering

Start simple. Focus on delivering one excellent product or service before diversifying. Too many offerings can dilute your brand.

5. You Can't Do It Alone

Build a team, whether it's employees, contractors, or mentors. Delegating tasks frees you to focus on what you do best.

> Mistakes and setbacks are inevitable. Use them as opportunities to learn and grow rather than as reasons to quit.



***Pete Flynn** is a retired vegetable farmer with a distinguished agricultural background. Upon earning a Bachelor of Science degree in agriculture from Michigan State University, he dedicated ten years to dairy farming before strategically transitioning to the cultivation of sweetcorn and vegetables. Notably, he established and managed a thriving retail market. With over 35 years of operational success, Mr. Flynn maintained a prominent farm market in Chester County. Currently, as a long-time member of the Pennsylvania Vegetable Growers Association, he contributes his expertise by serving on the board as President.*

6. The Importance of Networking

Relationships can make or break your business. Build a strong network of peers, mentors, and potential collaborators.

7. Expect Failure and Learn from It

Mistakes and setbacks are inevitable. Use them as opportunities to learn and grow rather than as reasons to quit.

8. Marketing Is a Non-Negotiable

Even the best product won't sell itself. Develop a clear marketing strategy and understand where your target audience spends their time.

9. Systems and Processes Save Time

Automate and streamline as much as you can. Clear systems and processes increase efficiency and make scaling easier.

Continued on next page

Asparagus Disease (continued from page 12)

Heavy rainfall tends to favor Phytophthora whereas high heat and drought stress may favor Fusarium. Control of Fusarium and Phytophthora rot is challenging as the pathogens persist in the soil and cultural and chemical control options are limited.

occur on 60-90% of the spears and may result in rejection of the crop, especially for fresh-market sales. Spots also occur on the asparagus ferns, affecting the main stem, secondary branches and needles (cladophylls). Severe infection of the fern can result in premature defoliation of the plant. Increase in the severity of purple spot disease is associated with extended periods of rainfall, fog or dew. Research has determined that the TOMCAST disease forecaster is a promising alternative to calendar-based spraying of fern in commercial asparagus fields. TOMCAST alerts growers when the environmental conditions are favorable for purple spot disease development (extended dew or rainy periods accompanied by warm temperatures). Effective fungicides applied according to the TOMCAST disease forecaster allows growers to manage purple spot disease of asparagus, while saving money and preserving the environment.

Soilborne Diseases. Fusarium spp. cause stem, crown, and root rot of asparagus and Phytophthora asparagi causes spear, crown, and root rot. While both pathogens may infect asparagus seedlings in the nursery and crowns after establishment in production fields, Phytophthora is especially devastating. Since asparagus is a perennial crop, crown rot may progress unnoticed initially. Heavy rainfall tends to favor Phytophthora whereas high heat and drought stress may favor Fusarium. Control of Fusarium and Phytophthora rot is challenging as the pathogens persist in the soil and cultural and chemical control options are limited. Treating crowns with fungicides before planting and fumigating crown nurseries and production fields have been used in recent years to improve crown health and enhance the longevity and productivity of the asparagus planting.

Things I Wish I Knew When I Started (continued from page 13)

10. Your Mindset Matters

Stay disciplined, manage stress, and keep a long-term perspective. A strong mindset can carry you through challenging times.

11. Know what auditors are looking for and manage your records as though you are preparing for an audit.

DOL will audit you during your busiest season.

12. Sweet corn tips.

A). Plantings between the 10th and 20th of May don't need insecticides.

B). Tighten up spray schedule when Hot and humid.

C). Stay one step ahead of IPM

The Impacts of Invasive Species on Honey Bees

Robyn Underwood
Penn State Extension
Suite 104, 4184 Dorney Park Rd. | Allentown, PA 18104
484-268-5208 | beekeeping@psu.edu

Invasive species have both positive and negative impacts on honey bees. Established pests such as varroa mites and small hive beetles cause harm, while invasive plants such as honeysuckle and Japanese knotweed are excellent sources of nectar. Here, we review various cases of the impacts of invasive species on honey bees and discuss species that are spreading, but not yet present in PA or the US.

Honey bees, themselves, are an invasive species. They were brought to the US on ships carrying European colonists in the 1600's. Their importance for the production of wax and honey made them a crucial import. Their value as pollinators of crops became critical in the 1930's when large monocultures became the norm in agriculture. Honey bees now contribute to more than $15 billion of crop production annually.

Invasive pests of honey bees have been introduced into the US on several occasions. The most impactful species has been the varroa mite, Varroa destructor. Varroa mites were introduced into the US in 1987 and quickly spread to honey bee colonies around the country. This parasite feeds on the fat bodies and hemolymph of adult and immature honey bees, spreading and activating deadly viruses. Much of a beekeepers' management throughout the year is aimed at reducing varroa mite populations. A failure to control mite population growth results in the death of the colony within 1-2 years.

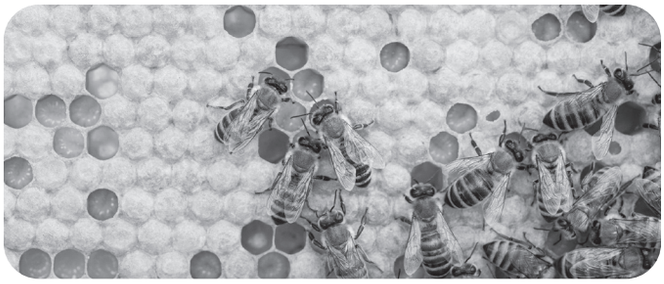
Robyn Underwood *received her BSc from the University of Delaware and her PhD from the University of Manitoba. As Penn State's Extension Educator of Apiculture, she conducts scientific research projects to study beekeeper-applied questions and brings the results of the projects to the beekeepers through extension products with an aim to improve the industry while making beekeeping a more successful venture.*

Small hive beetles, Aethina tumida, were introduced into the US in the mid-1990's. These pests can result in significant economic losses for beekeepers. They enter hives to consume stored food, defecating in honey and causing it to ferment and run out of the combs. Strong colonies can keep beetles under control, but weak colonies can become overrun with beetles.

Varroa mites were introduced into the US in 1987 and quickly spread to honey bee colonies around the country. This parasite feeds on the fat bodies and hemolymph of adult and immature honey bees, spreading and activating deadly viruses. Much of a beekeepers' management throughout the year is aimed at reducing varroa mite populations.

Continued on next page

The Impacts of Invasive Species on Honey Bees (continued from page 15)



In addition, honey supers removed from hives for extraction are extremely vulnerable and can be completely ruined in just a few days.

Yellow-legged hornets, Vespa velutina, were introduced into Georgia, USA in 2023. These stinging wasps are voracious predators of honey bees. Their habit of hawking foraging bees as they leave the hive cause the colony to halt foraging activities. Colonies decline and can be killed outright by wasp attacks. Officials are aiming to eradicate these serious pests. They are currently restricted to Georgia and South Carolina.

Tropilaelaps mites, Tropilaelaps spp., have not yet been introduced into the US. The distribution of these mites, which originated in Asia, has been expanding. These mites are predicted to be more destructive than varroa mites, so authorities are carefully tracking their movements.

Some invasive plant species have been highly beneficial to honey bees and beekeepers. Knapweed, dandelions, honeysuckle, autumn olive, bee bee trees and other invasive species are important sources of nectar. Japanese knotweed, introduced as an ornamental from Asia in the 1800's, is now found in 42 states. This highly invasive plant is an excellent source of nectar for honey bees in the fall. The honey that is made is rich, dark red, pleasant tasting and high in antioxidants and vitamins.

The most interesting result of the impact of invasive species on honey bees is the relationship of honey bees, spotted lanternflies, and Tree of Heaven. The introduction of spotted lanternflies, Lycorma delicatula, to Berks County, PA in 2014 has led to an abundance of unique fall honey wherever lanternflies become established. As lanternflies become adults, they gather together to feed on the sap of trees, with a special appetite for Tree of Heaven. Tree of Heaven, Ailanthus altissima, was introduced to the US over 200 years ago. As lanternflies feed on the sap, they excrete large quantities of sugar water known as honeydew. Honey bees collect the honeydew and process and store it in their hives as honey. This honeydew honey is now well known and accepted. In addition, current research is shedding light on its medicinal properties and ability to heal wounds.

In conclusion, invasive species can have either a negative or positive impact on honey bees. Let's all hope that harmful species are kept outside our borders.

Green Beans, Seeds to Table

Art King
Harvest Valley Farms

It all starts in a high tunnel with green bean transplants in April. Then we move to transplants through black plastic in the field in May. At the same time we will plant seeds through black plastic in the field. There is no question that your yields are much better growing green beans through black plastic than just in the soil. Throughout the season we mainly grow beans in the soil, but if we have some plastic open, we will seed that as well. All the beans grown in plastic are able to be irrigated. About half of the beans grown in the soil could be irrigated.

Marketing

All our green beans are sold retail. At our farm market we sell them by the pound. Customers select the beans and put them into plastic bags provided and the beans are weighed and priced at the checkout. We sell them for 4.99 lb. Because they are handpicked, they are perfect. At 22 lb. per bushel the gross profit is 110.00 per bushel. At the farmers markets beans are sold in quart boxes, but weighed at 1 lb., and sold for 5.00 each quart. Green Beans are one of the most popular items at the farmers markets.

Green beans are in the top 6 crops that we grow. They are a very high value crop. Because of that it is worth it for use to pick them by hand. A main attribute of that is that we sell all of our green beans retail. At an average cost of 18.00 per bushel for harvesting alone, it would not be worth it for us to sell wholesale. Some of the beans are grown in plastic and some are not.

Varieties

Our green bean variety is Tema, and that makes all the difference. They are thin, easy to pick, and most importantly, very flavorful and sweet. They have the least amount of fiber of any bean we have ever tried to grow. That is a problem, though, we have not been able to find a substitute when seed supply is low. The yellow bean variety is Carson Yellow and we only grow a limited amount of them.

Post Harvest

As with any vegetable, post-harvest handling is critical. We always harvest beans in the mornings, then they are washed immediately and put in a 38-degree cooler in solid plastic 1 bushel containers with holes in the bottoms.

Green Beans

China is the world's largest producer of green beans at over 16 million metric tons.

Green Beans are a powerhouse source of vitamins and fiber. Most important is vitamin K, 25% of the daily-recommended amount. They are a very good source of vitamin A, notably through their concentration of beta-carotene, and an excellent source of vitamin C. These two nutrients are important antioxidants that work to reduce the amounts of free radicals in the body. A recent study shows that steaming of green beans may provide cholesterol-lowering benefits by binding together with bile acids.

With this much nutrition in such a delicious food; we should all make green beans a regular part of our diet.

Snap Bean Variety Trials

Emmalea G. Ernest
University of Delaware Carvel Research and Education Center
16483 County Seat Hwy | Georgetown, DE 19947
emmalea@udel.edu

The UD Extension Vegetable and Fruit Research Program has been trialing snap bean varieties at the Carvel Research and Education Center in Georgetown, Delaware annually since 2017. At this location, snap beans planted from late May through early July are reliably exposed to extended periods with high night temperatures. Trials planted in mid-May are sometimes heat stressed. Mid to late July plantings are consistently the highest yielding because plants establish well in warmer soils and heat stress during flowering is less likely in Aug/Sep. Most trials have been of bush growth habit varieties that are harvested only once. In 2024 we also tested eleven climbing varieties, which were harvested multiple times (Table 1).

Quality grading is an important part of evaluating varieties for heat stress tolerance. In heat stressed trials the heat tolerant varieties produce a higher percent marketable pods.

The highest yielding climbing snap bean in the 2024 trial was Cobra. The following varieties also performed well in the trial: Early Riser, Aunt Bea's, Witsa and Helda.

Emmalea Ernest *is the Extension Fruit and Vegetable Specialist and an Assistant Professor at University of Delaware. Emmalea has been with UD Cooperative Extension since 2004. Her research is focused on abiotic stress tolerance, fruit and vegetable variety evaluation, and lima bean breeding and genetics.*

There were 30 round-podded bush varieties tested in 2024 (Table 2). The May 23 planting experienced heat and drought stress, the June 6 planting experienced some heat stress but also stand loss from pythium after plants were well established. PV966 was the highest yielding variety in the May trial but had lower yields in the June planting due to stand loss from pythium. The other high yielding varieties in the May planting were: PV 857, PL 0008 and Greenback.

The highest yielding varieties in the June planting were: Byrd, HM5101, RR 3006, and R302088. The

Table 1. Climbing Snap Bean Varieties Tested in 2024

Variety	Pod Description	Pod Length (cm)	Marketable Yield (lbs/20 ft)
Cobra	round, green	16.9	23.51
Early Riser	flat, green	18.0	15.96
Aunt Bea's Pole	intermediate, streaked	12.7	15.43
Witsa	round, green	17.7	14.76
Helda	flat, green	17.8	14.08
Ideal Market	round, green	12.3	13.46
Seychelles	round, green	12.2	12.95
Louisiana Purple Pod	round, purple	13.1	9.29
Gold Nectar	flat, wax	15.9	6.70
Kew Blue	flat, purple	14.3	2.97
Fortex	round, green	20.0	1.72

Snap Bean Variety Trials (continued from page 18)

varieties with the lowest number of plants killed by pythium were: RR 3006, BEX162, HM510, Caprice, PV 4043, PV 4041, R302088. The varieties with the highest number of plants killed by pythium were: Nyquist, BEX069, Jaguar, Fraser and BEX089.

With a variety of biotic and abiotic stresses present during the 2024 season, no single variety performed well in both trials.

Table 2. Round Podded Varieties Tested in 2024

Variety	May 23 Planting				June 6 Planting				Pythium*
	Total Yield		Marketable Yield		Total Yield		Marketable Yield		
Byrd	1,202	e-j	525	c	7,654	abc	6,995	a	8.8
HM5101	1,877	d-g	766	c	8,349	a	6,450	ab	2.3
PV 966	6,873	a	4,569	a	4,572	d-h	2,605	e-m	21.5
Greenback	4,371	bc	3,139	b	5,374	c-g	3,135	d-j	9.5
RR 3006	550	g-j	100	c	6,712	a-d	6,125	abc	0.5
PV 857	6,334	a	4,177	ab	3,944	c-j	1,767	g-m	15.0
PL 0008	5,687	ab	4,150	ab	5,205	c-g	1,540	h-m	13.0
R302088	2,480	def	742	c	5,913	a-f	4,902	a-d	3.8
SB4829	2,893	cd	1,186	c	5,419	c-g	4,037	c-f	6.3
NYQUIST	1,636	d-i	709	c	6,404	a-c	4,422	b-e	25.0
Caprice	480	g-j	39	c	8,105	ab	4,677	b-e	2.5
Peary	248	hij	45	c	5,446	b-g	4,432	b-e	8.5
SVGG2123	271	hij	66	c	5,000	c-g	4,321	b-e	17.8
PV 4043	1,317	e-j	550	c	4,218	d-i	3,799	d-g	3.0
HMC019396	650	g-j	396	c	4,525	d-h	3,568	d-h	10.8
HMC010522	664	g-j	211	c	3,984	e-j	3,494	d-i	6.3
RR2015	1,334	e-j	707	c	2,963	g-k	2,807	d-l	17.8
Fraser	1,095	f-j	529	c	3410	g-k	2,919	d-k	32.0
PV4041	1,668	d-h	992	c	3,380	f-k	2,047	f-m	3.5
Bartram	2,682	de	939	c	4,985	c-h	1,549	h-m	17.3
BEX089	719	g-j	257	c	2,308	h-k	2,075	f-m	37.8
BEX069	1,598	d-j	707	c	1,835	ijk	1,334	j-m	30.0
SVGV2138	1,986	d-g	760	c	1,509	jk	1,102	j-m	13.5
RR 2006	1,338	c-j	485	c	2,921	g-k	1,286	j-m	12.0
BEX100	1,272	e-j	312	c	3,162	g-k	1,382	i-m	10.8
Jaguar	1,541	d-j	848	c	1,046	k	668	lm	30.3
BEX162	103	j	14	c	1,561	ijk	1,415	i-m	2.0
Silverado	975	f-j	491	c	1,362	jk	871	klm	20.5
PV981	663	g-j	291	c	1,312	jk	791	klm	14.0
Emotion	149	ij	76	c	737	k	519	m	19.3
p-value	***<0.000***		***<0.000***		***<0.000***		***<0.0001***		
LSD	**1,508**		**1,237**		**2,678**		**2,145**		
cv	**58.9**		**91.7**		**46.4**		**52.6**		

Penn State Flower Trials Best in Show 2023

Krystal Snyder, Penn State Extension, Interim Flower Trial Director
Kls6590@psu.edu

Agastache

Summerlong™ 'Coral' Drewin Perennials

Alstroemeria

Inticancha. 'Paraiso' HilverdaFlorist

Summer Paradise. 'Summer Chic' HilverdaFlorist

Summer Paradise. 'Summer Rose' HilverdaFlorist

Angelonia

Angelface. 'White IMP' Proven Winners

Begonia

'BIG. White Bronze Leaf (seed)' Begonia Benary

'BIG. White Green Leaf IMP (seed)' Begonia Benary

'Birthday Bash™ Chocolate Cherry' Begonia Syngenta Flowers

'Birthday Bash™ Cotton Candy' Begonia Syngenta Flowers

'Birthday Bash™ Raspberry Sherbet' Begonia Syngenta Flowers

'BK Collection. Vermillion Hot Pink' Begonia Beekenkamp Plants

'Dragon Wing. Pink Bronze Leaf (seed)' Begonia PanAmerican Seed

'FlowerBall F1 Pink (seed)' Begonia Cerny Seed

'FlowerBall F1 Red (seed)' Begonia Cerny Seed

'FlowerBall F1 Rose (seed)' Begonia Cerny Seed

'FlowerBall F1 White (seed)' Begonia Cerny Seed

'Gryphon (seed)' Begonia PanAmerican Seed

'Hula™ Spreading Pink (seed)' Begonia PanAmerican Seed

'Hula™ Spreading Red (seed)' Begonia PanAmerican Seed

'Hula™ Spreading Red and White Mixture (seed)' Begonia PanAmerican Seed

***Krystal Snyder** is a Horticulture Extension educator based in Northeast PA focusing on greenhouse floriculture, hydroponics, green industry and interim director of Penn State Flower Trials. She joined Penn State Extension in March of 2019. Before joining Penn State Extension, Krystal worked as a technical specialist and was an adjunct professor at Delaware Valley University. Krystal holds a BS in Horticulture from Delaware Valley University and is a current graduate student at Penn State University.*

'Hula™ Spreading White (seed)' Begonia PanAmerican Seed

'I'CONIA. Bachelorette Red' Begonia Dümmen Orange™

'I'CONIA. First Kiss Del Sol' Begonia Dümmen Orange™

'Megawatt™ Pink Bronze Leaf (seed)' Begonia PanAmerican Seed

'Megawatt™ Pink Green Leaf (seed)' Begonia PanAmerican Seed

'Megawatt™ Red Bronze Leaf (seed)' Begonia PanAmerican Seed

'Megawatt™ Red Green Leaf (seed)' Begonia PanAmerican Seed

'Megawatt™ White Green Leaf (seed)' Begonia PanAmerican Seed

'Spacestars. Avior' Begonia Rex Beekenkamp Plants

'Spacestars. Haedi (Rex 4699)' Begonia Rex Beekenkamp Plants

'Spacestars. Maia IMP' Begonia Rex Beekenkamp Plants

Penn State Flower Trials Best in Show 2023 (continued from page 20)

‘Spacestars. Syrma (Rex 4698)’ Begonia Rex Beekenkamp Plants

‘Viking White on Green (seed)’ Begonia Sakata Seed America

Caladium

‘Little Gem’ Caladium

‘Rio Summer’ Caladium Classic Caladiums, LLC

Calibrachoa

Bloomtastic ‘Blue Sky’ Dümmen Orange™

Bloomtastic ‘Peach Grenadine 2025’ Dümmen Orange™

Cha-Cha™ ‘Frosty Lemon’ Ball Floraplant

Eyeconic™ ‘Orange’ Danziger Flower Farm

MiniFamous. Neo ‘Red Shuffle’ Selecta One

MiniFamous. Uno ‘Pink Starfruit’ Selecta One

Celosia

‘Burning Embers’ Sakata Seed America

Bright Sparks™ ‘Pink (seed)’ Syngenta Flowers

Kelos. Fire ‘Orange’ Beekenkamp Plant

Kelos. Fire ‘Purple’ Beekenkamp Plants

Coleus

‘All That Jazz’ Kientzler North America

‘Mojave Sunrise’ Kientzler North America

‘Paprika’ Kientzler North America

‘Queen’ Kientzler North America

‘Sangria Splash’ Kientzler North America

‘Skeletal’ Kientzler North America

‘Solar Fire’ Kientzler North America

ColorBlaze® ‘Lime Time’ Proven Winners

Down Town ‘Greenville’ Dümmen Orange™

Down Town ‘Miami Magic’ Dümmen Orange™

Down Town ‘Nashville’ Dümmen Orange™

Down Town ‘NYC Nights’ Dümmen Orange™

Down Town ‘Santa Monica’ Dümmen Orange™

Down Town ‘Vegas Neon’ Dümmen Orange™

Premium Sun ‘Coral Candy (seed)’ PanAmerican Seed

Premium Sun ‘Crimson Gold (seed)’ PanAmerican Seed

Combinations

Durabella. ‘Finger Paints’ Danziger Flower Farm

Garden Party HOT SPOT ‘Amalfi Coast’ Dümmen Orange™

Garden Party HOT SPOT ‘Olympic Valley’ Dümmen Orange™

Kwik Kombos™ ‘Picnic in the Park™ Mix’ Syngenta Flowers

MixMasters™ ‘Passion Project’ Ball Floraplant

MixMasters™ ‘Peppermint Dreams’ Ball Floraplant

Playlist™ Combo ‘Boombox Boggie’ Sakata Seed America

Playlist™ Combo ‘Choirmaster’ Sakata Seed America

Playlist™ Combo ‘Dreamy Duet’ Sakata Seed America

Playlist™ Combo ‘Electric Lady’ Sakata Seed America

Playlist™ Combo ‘Love Ballad’ Sakata Seed America

Playlist™ Combo ‘Pass the Aux’ Sakata Seed America

Playlist™ Combo ‘Pop Life’ Sakata Seed America

Playlist™ Combo ‘Rockabilly Red’ Sakata Seed America

Playlist™ Combo ‘White Lightning’ Sakata Seed America

Cuphea

‘Vermillionaire.’ Cuphea Proven Winners

Continued on next page

Penn State Flower Trials Best in Show 2023 (continued from page 21)

Cyperus

'Abby (seed)' Cyperus Benary

Dichondra

Silver Surfer™ 'ApeX (seed)' Dichondra Benary

Geranium

Falcon F1 POLLEN-FREE 'Salmon (seed)' Cerny Seed

Sarita 'Wild Salmon' Geranium – Interspecific Dümmen Orange™

Solera™ 'Fuchsia' Geranium – Interspecific Selecta One

Solera™ 'Lavender' Geranium – Interspecific Selecta One

Solera™ 'Orange' Geranium – Interspecific Selecta One

Super Moon™ 'Violet' Selecta One Geranium - Zonal

Impatiens - hybrida

Spectra™ 'Magenta' Syngenta Flowers

Spectra™ 'Orange IMP' Syngenta Flowers

Spectra™ 'Pink' Syngenta Flowers

Spectra™ 'White' Syngenta Flowers

SunPatiens. Compact 'Classic White' Sakata Seed America

SunPatiens. Compact 'Lavender' Sakata Seed America

SunPatiens. Compact 'Purple Candy IMP' Sakata Seed America

SunPatiens. Compact 'Red Candy' Sakata Seed America

SunPatiens. Vigorous 'Orchid' Sakata Seed America

SunPatiens. Vigorous 'Purple' Sakata Seed America

SunPatiens. Vigorous 'Red' Sakata Seed America

Impatiens - New Guinea

Rokoko 'Beatrice' Kientzler North America

Rokoko 'White 2022' Kientzler North America

Impatiens walleriana

Beacon. 'Bright Red (seed)' PanAmerican Seed

Beacon. 'Chicago Mix (seed)' PanAmerican Seed

Beacon. 'Coral IMP (seed)' PanAmerican Seed

Beacon. 'Lipstick (seed)' PanAmerican Seed

Beacon. 'Orange (seed)' PanAmerican Seed

Beacon. 'Otway Mix (seed)' PanAmerican Seed

Beacon. 'Rose (seed)' PanAmerican Seed

Beacon. 'Salmon (seed)' PanAmerican Seed

Beacon. 'Violet Shades (seed)' PanAmerican Seed

Beacon. 'White (seed)' PanAmerican Seed

Rockapulco. 'Red IMP' Proven Winners

Lantana

Bandolero™ 'Pineapple' Syngenta Flowers

GEM™ 'Diva Pink' Danziger Flower Farm

Havana 'Harvest Moon 2025' Dümmen Orange™

Heartland 'Really Red 2025' Dümmen Orange™

Lucky™ 'Gold' Ball Floraplant

Shamrock™ 'Red' Ball Floraplant

Tropic® 'Mango®' Beekenkamp Plants

Mandevilla

Bush 'Tropica Medesto Red' Ball Floraplant

Bush 'Tropica Medesto White' Ball Floraplant

Bush 'Tropica Unico Fuchsia' Ball Floraplant

'Tropica Grande Red' Ball Floraplant

Penn State Flower Trials Best in Show 2023 (continued from page 22)

Petunia

BK Semi Trailing 'PTST 0065' Beekenkamp Plants

BOOM!™ HD 'Rose Star (seed)' Benary

Capella™ 'Pink Morn' Danziger Flower Farm

Capella™ 'Rim Raspberry' Danziger Flower Farm

Dekko™ 'Maxx™ Pink' Syngenta Flowers

Dekko™ 'Rose Vein' Syngenta Flowers

Durabloom® 'Electric Lilac' Dümmen Orange™

E3 Easy Wave® Spreading 'Burgundy Velour (seed)' PanAmerican Seed

E3 Easy Wave® Spreading 'Navy Velour (seed)' PanAmerican Seed

E3 Easy Wave® Spreading 'Neon Rose (seed)' PanAmerican Seed

E3 Easy Wave® Spreading 'Pink Passion (seed)' PanAmerican Seed

E3 Easy Wave® Spreading 'Rose (seed)' PanAmerican Seed

Painted Love™ 'Purple' Syngenta Flowers

SuperCal® 'Shocking Pink' Sakata Seed America

SuperCal® Premium 'Rose Pink' Sakata Seed America

Supertunia Mini Vista® 'Yellow' Proven Winners

Supertunia Tiara® 'Pink' Proven Winners

Supertunia Vista® 'Bubblegum®' Proven Winners

Supertunia® 'Bermuda Beach IMP' Proven Winners

Surfinia® 'Deep Red' Suntory Flowers

Surfinia® 'Heavenly Cabernet' Suntory Flowers

Tea™ 'Purple Vein' Beekenkamp Plants

Tea™ 'Rose Morn' Beekenkamp Plants

Portulaca

Mojave. 'Pink' Proven Winners

Mojave. 'Yellow' Proven Winners

Sundial 'Valentine Mix (seed)' Benary

Salvia

Unplugged. 'So Blue™' Proven Winners

Unplugged. 'White' Proven Winners

Scaevola

'Lavender Blessing' Danziger Flower Farm

'Pink Brilliance' Selecta One

Scala 'Purple Bird 2025' Dümmen Orange™

Stardiva™ 'Pink' Proven Winners

Surdiva. 'Blue Violet IMP' Suntory Flowers

Surdiva. 'Fashion Pink' Suntory Flowers

Surdiva. 'Fashion Pink IMP' Suntory Flowers

Whirlwind. 'White' Suntory Flowers

Vinca (Catharanthus)

Nirvana. XDR 'Blackberry' Syngenta Flowers

Nirvana. XDR 'Blue Halo' Syngenta Flowers

Nirvana. XDR 'Blush Splash' Syngenta Flowers

Nirvana. XDR 'Cranberry Halo' Syngenta Flowers

Soiree. Double 'Orchid IMP' Suntory Flowers

Soiree. Double 'Pink IMP' Suntory Flowers

Titan-ium™ 'Apricot (seed)' PanAmerican Seed

Titan-ium™ 'Blush (seed)' PanAmerican Seed

Titan-ium™ 'Dark Red (seed)' PanAmerican Seed

Titan-ium™ 'Mix (seed)' PanAmerican Seed

Titan-ium™ 'Polka Dot (seed)' PanAmerican Seed

Titan-ium™ 'Punch (seed)' PanAmerican Seed

Titan-ium™ 'Really Red (seed)' PanAmerican Seed

Titan-ium™ 'White (seed)' PanAmerican Seed

IoT-Based Precision Monitoring System for Soilless Leafy Greens

Chenchen Kang[1,2], Xinyang Mu[1,2], Aline Novaski Seffrin[3], Francesco Di Gioia[3], Long He[1,2]
cqk5621@psu.edu, muxinyan@msu.edu, akn5598@psu.edu, fxd92@psu.edu, luh378@psu.edu

This study introduces an integrated Internet of Things (IoT) and computer vision system to enhance plant growth monitoring in Controlled Environment Agriculture (CEA) systems utilizing soilless growing systems (SGS). The core innovation is a Recursive Segmentation Model (RSM) designed for continuous tracking of bok choy growth, demonstrating significant improvements over conventional image segmentation methods.

Chenchen Kang *is a postdoctoral researcher at Penn State Fruit Research and Extension Center since 2023. He received his PhD in Biological and Agricultural Engineering from Washington State University. His research focuses on specialty crop automation.*

Major Topics and Important Points

1. Motivation and Objectives

Traditional crop monitoring in CEA systems is labor-intensive and lacks the temporal resolution needed to capture plant growth dynamics effectively. This research aimed to develop an IoT-enabled system paired with a novel RSM to provide automated, continuous monitoring and detailed analysis of plant growth. Specific objectives included:

- Designing an IoT system for real-time image and environmental data collection.
- Developing an RSM to segment individual plants sequentially and track their growth.

2. IoT-Enabled Monitoring System

The IoT system integrates a ZED X Mini stereo camera and NVIDIA Jetson board for six-hourly image capture and processing. Nutrient solution parameters (pH and EC) are also monitored using sensors. Images and data are synchronized to cloud storage for real-time access. This framework facilitates consistent and high-resolution data acquisition crucial for the RSM's operation.

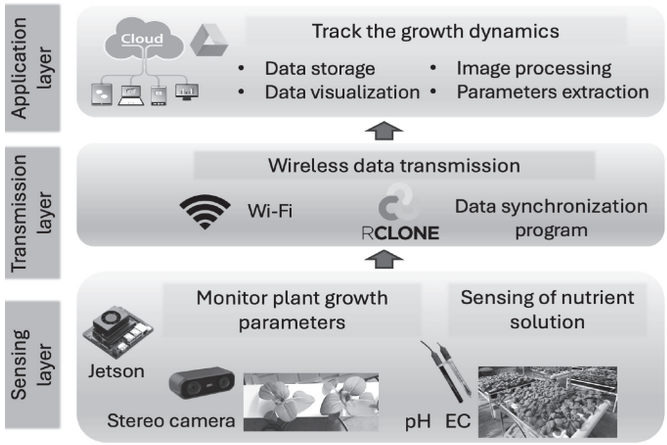


Figure 1. The IoT architecture of the vegetable growth monitoring system.

3. Recursive Segmentation Model (RSM)

The RSM builds on the Segment Anything Model (SAM) by incorporating outputs from previous segmentations as inputs for subsequent images. This recursive approach enhances segmentation accuracy over time, addressing challenges such as overlapping foliage in dense crop canopies.

Key Results: The RSM achieved an Intersection over Union (IoU) score of 0.99 during early growth stages and maintained a robust 0.90 score at later stages, outperforming SAM's single-point and auto-mask methods.

4. Growth Monitoring and Analysis

Leaf coverage area was tracked daily using segmentation results. The system captured

[1] Fruit Research and Extension Center, Penn State University, Biglerville, PA, USA
[2] Department of Agricultural and Biological Engineering, Penn State University, Biglerville, PA, USA
[3] Department of Plant Science, Penn State University, State College, PA, USA

IoT-Based Precision Monitoring System for Soilless Leafy Greens (continued from page 24)

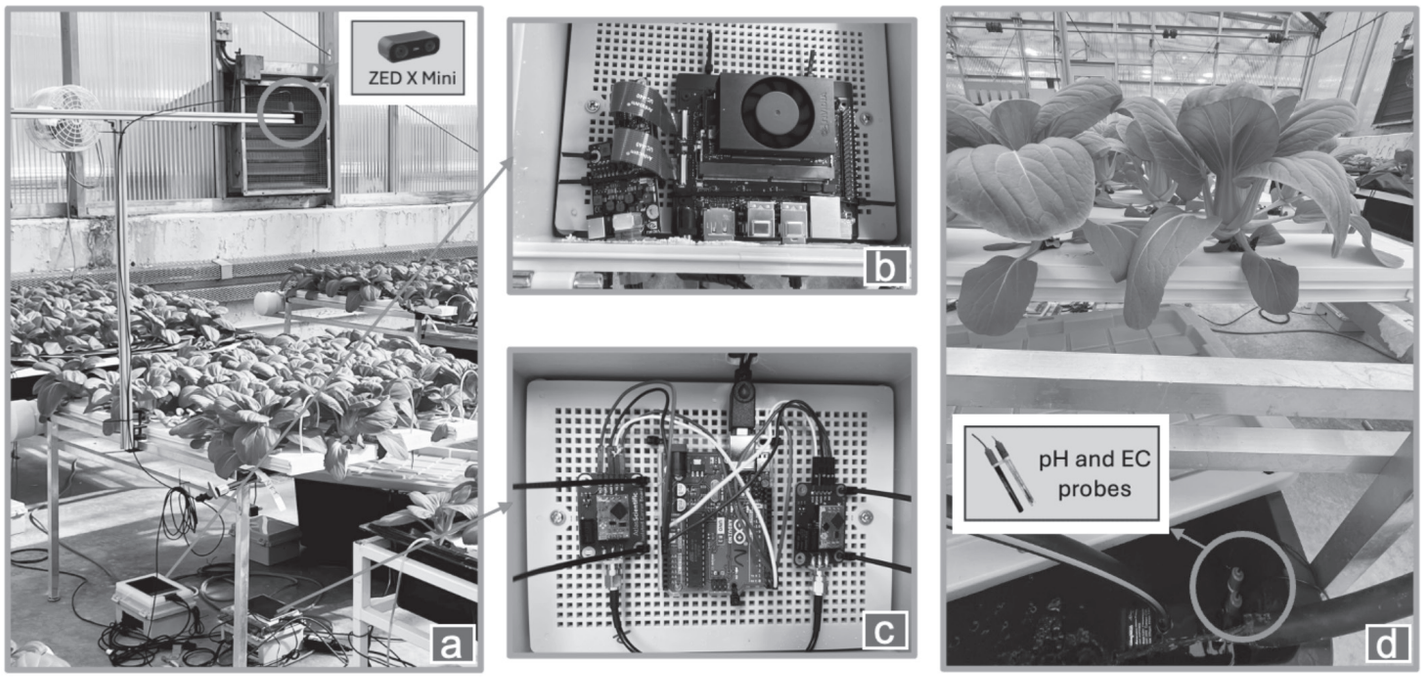


Figure 2. (a) An IoT-enabled vegetable growth monitoring system was set up in the greenhouse; **(b)** System control and data processing tasks were conducted using an NVIDIA Jetson board; **(c)** The pH and EC sensors interfaced with an Arduino Nano microcontroller board for data acquisition. **(d)** A pH sensor and an EC sensor were immersed in the nutrient reservoir tank to track changes in the nutrient solution.

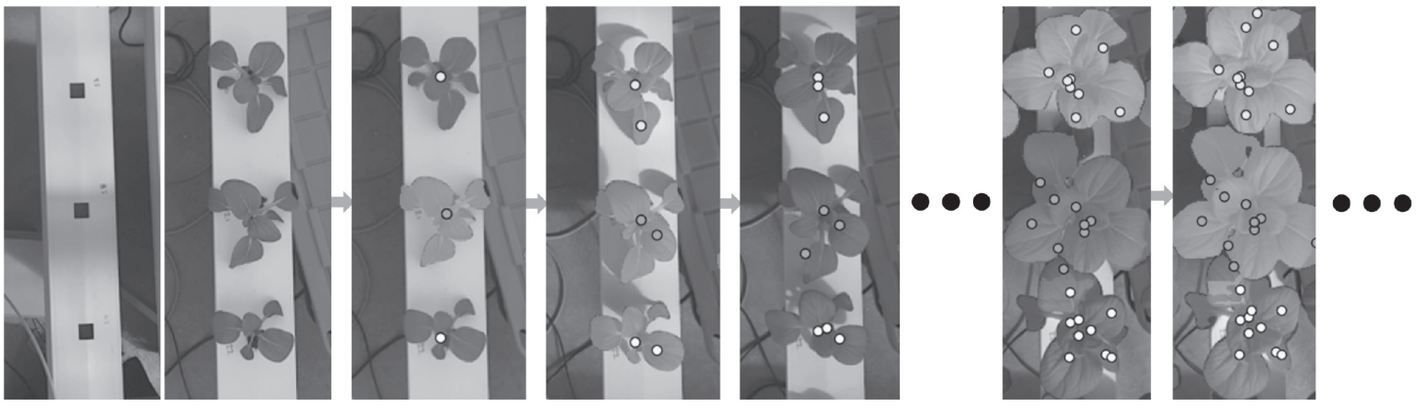


Figure 3. Recursive Segmentation Model (RSM) continuously accumulates randomly extracted points from previous masks, which serve as input for the next image segmentation process.

growth dynamics, showing a linear increase in leaf area until spatial constraints caused growth to plateau. Temporal variations in leaf coverage due to overlapping foliage were noted, emphasizing the need for enhanced 3D monitoring methods.

5. Future Research Directions

Incorporating 3D point cloud data and multi-angle imaging could improve accuracy. The system's adaptability for other crops and setups, such as lettuce or deep-water culture systems, will be explored.

Continued on next page

IoT-Based Precision Monitoring System for Soilless Leafy Greens (continued from page 25)

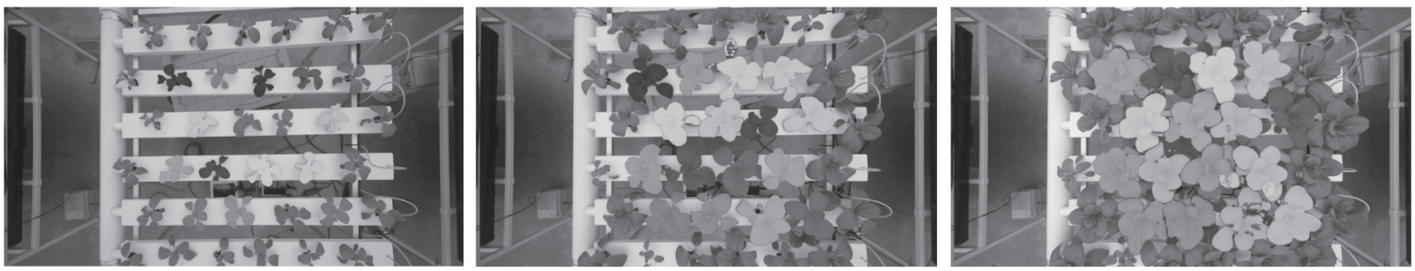


Figure 4. Tested on bok choy grown in an NFT (nutrient film technique) SGS, the integrated system developed successfully segmented individual plants and tracked leaf coverage area throughout their growth cycle.

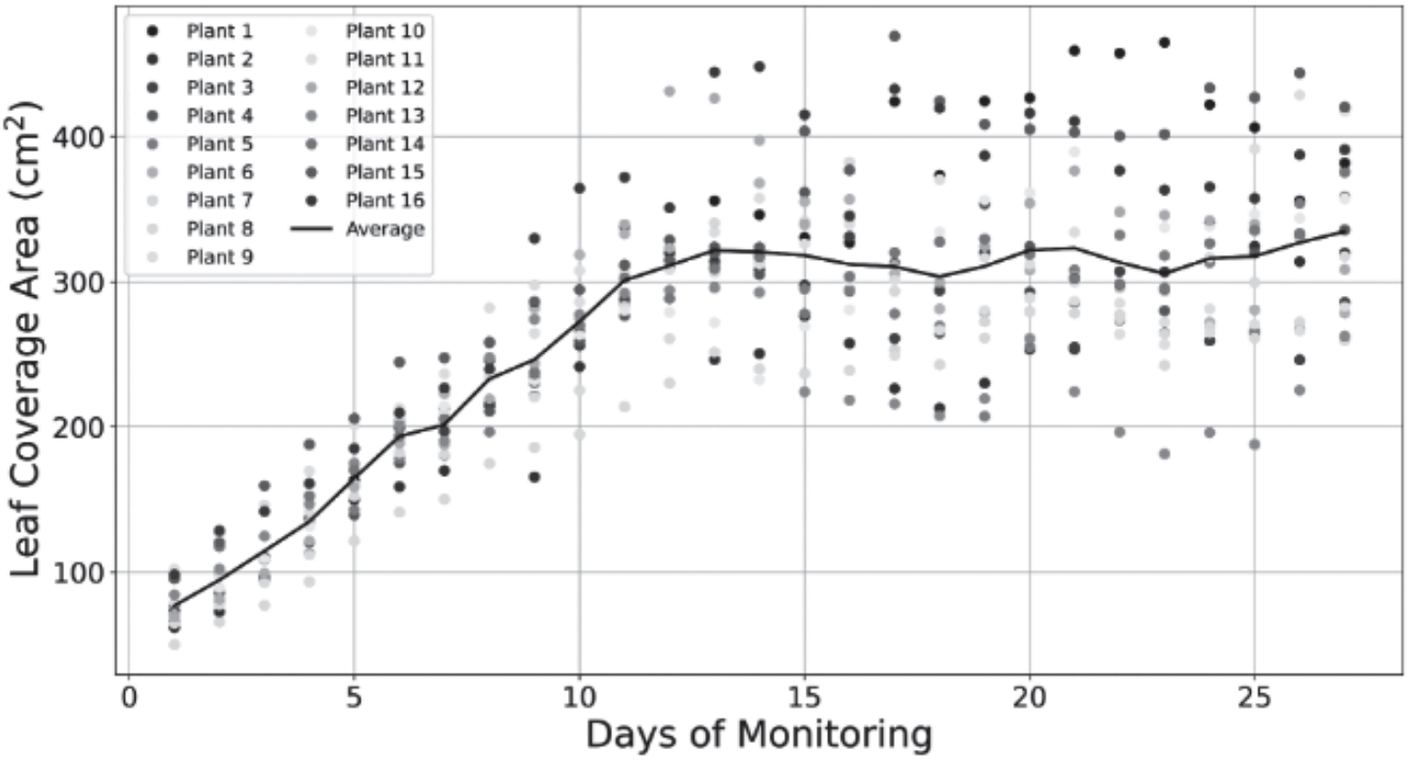


Figure 5. Scattered plot including leaf coverage area points for each bok choy plant and average leaf surface area growth curve.

Conclusion

The integration of IoT and RSM provides a scalable solution for automated, precise growth monitoring in CEA systems. This system enhances resource efficiency, facilitates data-driven crop management, and paves the way for improved agricultural practices in controlled environments.

The Art of Using Cover Crops in High Tunnels

Judson Reid and Lori Koenick
Cornell Cooperative Extension

High tunnels, or soil-based greenhouses, help vegetable farmers extend their growing season while increasing crop quality and yield. Within these intensive production systems where crop rotation and leaching events are limited, soil health and productivity decline over time due to fertility and compaction challenges, and rising pH, soluble salts, phosphorus and calcium levels.

Cornell Cooperative Extension is researching cover crops for high tunnel growers to better manage fertility and improve soil health. In the field, cover cropping has well documented benefits. Cover cropping has this same potential in high tunnels to build soil health. Our work has shown that winter cover cropping in high tunnels has the potential to add organic matter, improve soil structure, support microbial activity, and help with nutrient management by scavenging leftover nitrogen and/or fixing nitrogen. For example, over a two-year period, cover crop plots increased organic matter on average by 6.7% while bare ground plots increased organic matter on average by 1.5%.

We have been focusing on tomatoes as our primary crop, as over 80% of high tunnels in New York grow tomatoes. High tunnel tomato growers have limited options when it comes to implementing a cover crop into their crop rotation due to calendar constraints. The tomato season typically ends in October and begins again in March. This focused our efforts on a cover crop system during the fall and winter months.

The first step in cover cropping in high tunnels is choosing a species. When deciding what cover crop(s) to grow, think about your goals, crop rotation in the tunnel, management practices, and timing. The three main groups of cover crops to consider are legumes, grasses and brassicas. Benefits depend on which species are grown and how long they are in the ground.

Judson Reid *is the Agriculture Critical Issue Leader for Cornell Cooperative Extension and oversees statewide programming in Emerging Crops, Food Systems, Urban Agriculture and Climate Resiliency. He conducts research and extension programs in soil nutrient management in high tunnel vegetables. Judson's agricultural roots are in Jefferson County, NY where he grew up baling hay, shoveling manure and drinking raw milk.*

Legumes are mainly grown for their ability to fix nitrogen from the atmosphere and add it to the soil. Other benefits include increasing organic matter and attracting beneficial insects.

Grasses (grains) are grown for vigorous biomass production that can add organic matter, increase soil aggregation and reduce compaction. They are grown as catch crops that scavenge excess nutrients, especially nitrogen, to prevent leaching after the vegetable crop is done. Grasses will germinate in colder soils more so than any other cover crop type.

Brassicas are grown to reduce compaction, and for disease and pest suppression potential.

Cover crop mixtures are increasingly gaining popularity. In a mix, we may find multiple grasses, legumes and brassicas together. The mixture may present benefits as different species respond to the changes in light, temperature and moisture within a high tunnel over the winter months. Grass/legume mixtures are most common. When creating a mixture, it is important to consider how well the species will get along in terms of growth form and termination time.

Continued on next page

The Art of Using Cover Crops in High Tunnels (continued from page 27)

Common winter cover crops in high tunnels in NYS

Type	Examples	Rates (lb/acre) *	Notes
Legumes	Field Pea	60 to 140	There are multiple varieties of field pea- Austrian Winter Pea is the most cold hardy.
	Hairy Vetch	15 to 40	
	Crimson Clover	15 to 30	
	Red Clover	5 to 15	
Grasses	Triticale	60 to 200	Order of cold soil germination, from earliest to latest: Wheat, Barley, Triticale, Rye
	Winter Wheat	60 to 120	
	Barley	50 to125	
	Cereal Rye	60 to 200	
	Oats	60 to 150	
	Annual ryegrass	10 to 30	
Brassicas	Tillage or Forage radish	6 to 15	Brassicas are very competitive in mixtures.
	Turnip	4 to 12	

High tunnel management should influence species selection. The equipment a grower has and whether they grow in permanent raised beds or not will all influence how cover crop biomass can be managed, terminated, and incorporated. Cover crops must be terminated at the appropriate stage of growth to maximize biomass and nitrogen contributions. For example, plant available nitrogen decreases in grain crops when they enter the boot stage and become 'stemmy'. Consider how difficult it may be to manage a cover crop that is not terminated on time and goes to seed.

Timing should influence species selection. In our work, we have used planting dates from early September to the end of October. In general, our work shows the earlier you plant the more biomass will be produced. Yet we have found some nuances and effects depend on the specific cover crop being grown.

Our work has shown a trend that the earlier in fall you can plant a cover crop, the more legume growth you can achieve. If a later fall date is needed (in order to keep harvesting tomatoes) the grass becomes more important, and biomass is maximized in late winter.

Regardless of when you plant your cover crop, termination should occur at least two weeks prior to planting the next vegetable crop. This time allows residue to break down, returning nutrients to the soil, taking longer in cold soils. If not terminated and incorporated in a timely fashion, the cover crop residue will decrease nutrient availability for vegetable crops.

Common cover crop termination methods include mowing, tarping, rolling, and tillage. Chemical termination is not recommended under cover.

Winter kill versus winter hardy. Some cover crop species are more winter hardy than others. Some species are described as "winter kill" meaning they will not survive freezing temperatures. They are grown for fall biomass production, die back in the winter still providing soil cover and make

The Art of Using Cover Crops in High Tunnels (continued from page 28)

spring management easier. These can be a great choice for farms with less tillage options. Certain cover crops winter kill in field settings but can survive in high tunnel settings, for example oats and radishes. To achieve winter kill in a high tunnel, the grower may need to roll up the sides of the tunnel for a few weeks to achieve freezing temperatures.

Pest outbreaks in cover crops are possible. In our work, we have seen occasional pest pressure in cover crops but have yet to see a significant transfer to the following vegetable crop. As we are attempting to improve sustainability and soil health, we do not recommend pesticides for the control of pests on winter high tunnel cover crops. The most common pests in our trials are aphids and armyworms. Aphids (multiple potential species) can target all of the major cover crop families and can transmit viruses to vegetable crops, potentially leading to crop loss. In some situations, it may be advised to terminate and incorporate a cover crop early if there are extensive aphid populations.

Cultural Management considerations

Promote quick, uniform germination. As this crop won't be exposed to rain, you'll need to make sure it's watered in well. The faster it germinates, the more time it has to grow before deep freezing temperatures! In our research, we've found a sprinkler set-up works well for ensuring wide, uniform coverage. Factor in your soil type and drainage when watering your cover crop in. In our trials, a single-day of watering helped germination and the cover crop did not need additional irrigation until spring.

Row covers can be used to help maximize biomass production. In our research, we have applied mid-weight row cover in January and left it over the cover crop until spring. Our work has shown a trend that the impact of row cover on biomass production may be more significant in later cover crop plantings.

Efficiency, Yield, and Quality of Bok Choy Grown in Alternative Soilless Systems

Aline Novaski Seffrin and Francesco Di Gioia
Department of Plant Science | Pennsylvania State University

The growing demand for high-quality, sustainably produced vegetables, and the increasing challenges posed by environmental pollution, urbanization, and climate change are driving the adoption of innovative agricultural technologies. Controlled environment agriculture (CEA) and soilless cultivation systems (SCS) offer significant potential to enhance food security, especially in densely populated regions with limited farmland and sub-optimal environmental conditions, such as the Northeastern United States. Recent studies show that these systems improve yield and quality when compared to traditional soil-based farming while enabling year-round production of fresh vegetables, improving resource use efficiency, and reducing reliance on pesticides by minimizing exposure to soilborne pests and pathogens.

Soilless cultivation, which allows plants to grow without soil, can be classified into two primary categories: i) water culture systems, which include the nutrient film technique (NFT), deep water culture (DWC), and the Kratky system; and ii) substrate culture systems, which use organic or inorganic growing media and are fertigated through subirrigation or drip irrigation. Each system has distinct advantages. For example, water culture systems are often preferred for leafy greens due to their high water and nutrient efficiency, while substrate culture is commonly used for fruiting vegetables. Substrate-based systems, such as those using drip irrigation or sub-irrigation, provide support to the root system and more flexibility in nutrient and water delivery.

The choice of the SCS can influence crop resource use efficiency, productivity, quality and overall sustainability. Selecting the most effective SCS for specific crops and conditions requires consideration on the initial investment, operational requirements, maintenance, and environmental adaptability. For instance, while most SCS require the use of electricity, the Kratky system or water gap method does not require the use of electricity. Evaluating these systems in terms of yield, resource use, and sustainability is critical to optimizing soilless vegetable production and addressing regional food security challenges. However, only a few studies have compared different soilless cultivation systems side-by-side.

***Aline Novaski** is a second-year Ph.D. student studying controlled environment agriculture, resource use efficiency, and quality assessment of leafy greens. Her research focuses on how light influences plant growth and aims to improve both the efficiency of vegetable production and their quality.*

Figure 1. Side-by-side comparison of alternative soilless growing systems using baby bok choy as a test crop in an experimental greenhouse at Penn State.

Efficiency, Yield, and Quality of Bok Choy Grown in Alternative Soilless Systems (continued from page 30)

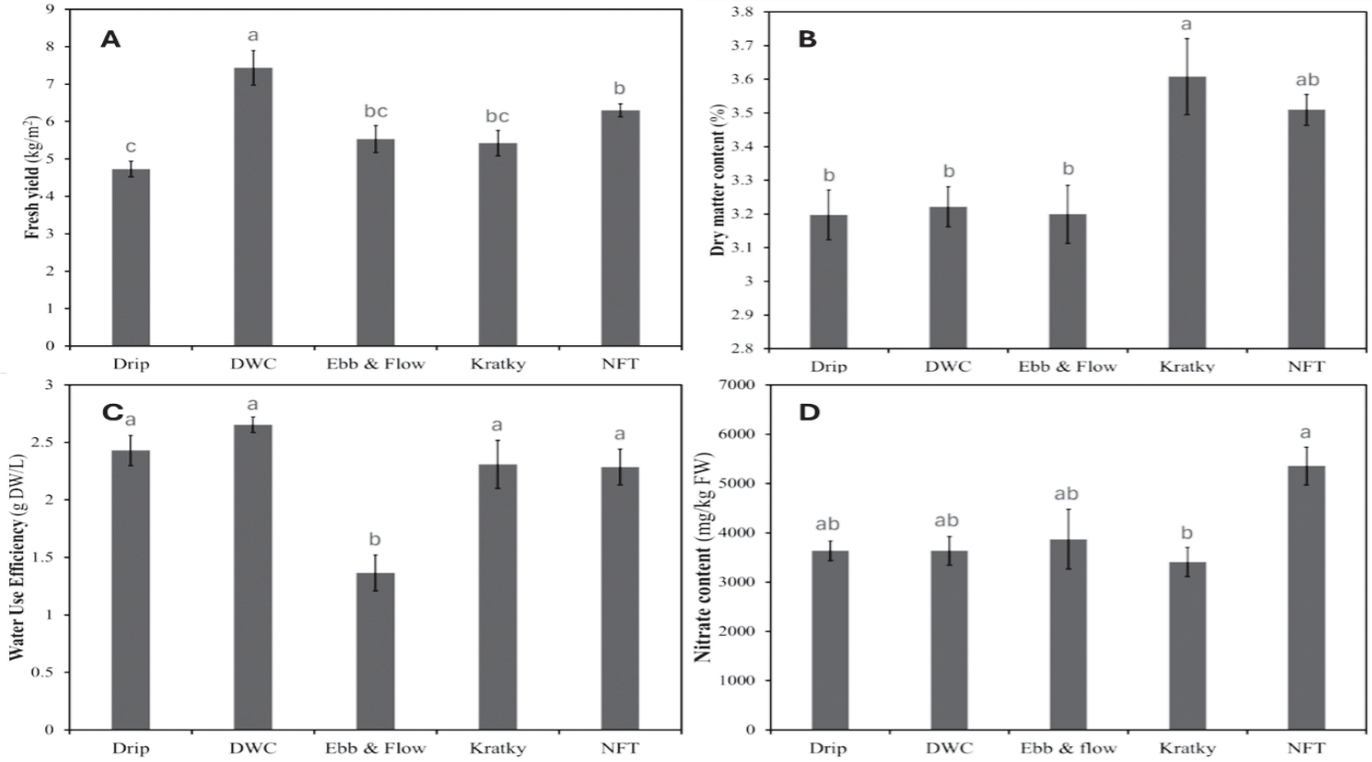


Figure 2. Fresh yield (A), dry biomass (B), water use efficiency (C) and nitrate content (D) of baby bok choy grown in alternative soilless growing systems.

Therefore, the objective of the present study was to compare side-by-side five different soilless growing systems (Drip irrigation, Ebb&Flow, DWC, Kratky, and NFT) evaluating their impact on resource use efficiency, yield, and quality performance of leafy vegetable crops. The study was conducted at the Penn State Greenhouse Facilities using baby Bok choy as a test crop (Figure 1). Bok choy, a leafy green belonging to the brassica family, and commonly known as non-heading Chinese cabbage, is a promising greenhouse crop and is well adapted to SCS. This high-value vegetable is rich in essential vitamins, minerals, fiber, and bioactive compounds known to contribute to human health.

Seedlings of baby Bok choy cv. “Li Ren Choi” were transplanted into hydroponic systems 17 days after sowing, on February 9, 2024. A standard nutrient solution was applied to all the SCS tested, and the volume of nutrient solution added throughout the experiment, and remaining at the end, was recorded to estimate the water and nutrient usage of each system. For the drip irrigation system, the total nutrient solution used was calculated based on the flow rate of the emitters (4L/h) and the duration of irrigation events. The pH, electrical conductivity (EC), and dissolved oxygen (DO) levels of the recirculating nutrient solution were measured weekly. The nutrient solution pH was maintained between 5.8 and 6.5. Baby Bok choy was harvested 36 days after planting,

At harvest, fresh yield ranged between 7.2 and 4.6 kg/m2 in DWC and drip-irrigation system, respectively (Figure 2A). The same systems had also the highest and lowest dry biomass (Figure 2B) and leaf area, respectively. The drip irrigation system consumed the least amount of water ensuring the highest water use efficiency, while

Continued on page 36

Comparative Analysis of Microbial Quality of Nutrient Solution and Bok Choy in Five Types of Hydroponic Systems

Auja Bywater[1], Aline S. Novaski[2], Francesco DiGioia[2], Jasna Kovac[1]

Background: Hydroponic farming is a growing field with limited data on the difference in microbial load among hydroponic system types. This study aimed to understand these differences using five systems and bok choy.

Methods: This study carried out a longitudinal assessment of microbial load of nutrient solutions and harvested bok choy grown in five different hydroponic farming systems over a 7-week growth period of bok choy. Bok choy was grown in five hydroponic systems in a greenhouse at Penn State University: Kratky, Nutrient Film Technique, Deep Water Culture, Ebb and Flow, and Drip Irrigation. Nutrient solution from individual systems, and the concentrated nutrient solution were sampled weekly for 7 weeks. At the conclusion of the study, outer leaves of bok choy from each system were sampled and tested for Aerobic Plate Count (APC) and coliform/*E. coli* count using Petrifilms. The composition of the microbiota of the samples was characterized through DNA isolation and sequencing of 16S rRNA V_4 amplicons. Lastly, PCR was conducted targeting the *invA* (*Salmonella*) and *stx1* and *stx2* (*E. coli*) genes. The study was conducted in duplicate with one replicate in fall (November, December), and the second during spring (February, March). Due to limited resources, coliform/*E. coli* were not enumerated during spring.

Statistical analysis: Bacterial count data were analyzed using ANOVA to assess the significance of differences in aerobic bacteria, *E. coli*, and coliform abundance among different hydroponic systems and seasons. The microbiota data were analyzed using the $DADA_2$ pipeline to determine bacterial composition. PERMANOVA was applied to assess the significance of differences in bacterial composition among different hydroponic systems and seasons.

Microbial quality of the nutrient solution and bok choy: At the end of the experiment, APC counts significantly differed across the systems in both replicates ($P<0.001$). APC counts in the fall ranged from 1.54 (Deep Water Culture) to 7.47 (Drip Irrigation) log CFU/ml. APC counts in the spring ranged from 2.6 (Ebb and Flow) to 6.43 (Drip Irrigation) log CFU/ml. In both seasons, the Drip Irrigation system nutrient solution had the highest averaged APC counts, and the Ebb and Flow and Deep Water Culture systems had the lowest averaged APC counts in fall and spring, respectively (Table 1). Coliform counts also significantly differed across systems ($P<0.001$) in the fall and ranged from 0.06 (Kratky) to 1.29 log CFU/ml (Ebb and Flow) ($p=0.96$). Overall, across all systems, APC counts did not significantly differ between seasons. However, APC and

Auja Bywater *is a Ph.D. candidate in Food Science at Penn State University. She holds an undergraduate degree in Public Health from Brigham Young University – Idaho and a Master's degree in Food Science and Technology from Virginia Tech. With a strong background in food safety, microbiology, and microbiome analysis, Auja has specialized in hydroponic farming and food safety research during her Ph.D. program. She is experienced in bioinformatics and statistical analysis, applying these to her research on microbial characteristics in agricultural systems.*

[1] Department of Food Science, The Pennsylvania State University, University Park, PA 16802

[2] Department of Plant Science, The Pennsylvania State University, University Park, PA 16802

Comparative Analysis of Microbial Quality of Nutrient Solution and Bok Choy in Five Types of Hydroponic Systems (continued from page 32)

Table 1. The aerobic bacteria and coliform counts by season, averaged by system.

System	Aerobic Bacteria Log CFU/ml	Coliforms Log CFU/ml	Aerobic Bacteria Log CFU/ml
Ebb and Flow	4.29	1.46	4.66
Drip Irrigation	5.58	3.49	5.44
Deep Water Culture	4.61	0.77	4.16
Kratky	4.5	0.65	4.17
Nutrient Film Technique	4.67	1.05	3.99

coliform counts did differ significantly within each of the systems over time in each season ($P<0.001$). No *E. coli* or *Salmonella* was detected. Salmonella was detected.

The APC counts on outer leaves of the bok choy at harvest ranged from 2.12 (Nutrient Film Technique) to 3.93 (Ebb and Flow) log CFU/ml in fall, and from 2 (Kratky, Ebb and Flow) to 3.57 (DI) log CFU/ml in spring. In the fall, coliform counts on outer leaves of the bok choy at harvest ranged from 0.77 (Kratky) to 2.77 log CFU/ml (Ebb and Flow). The systems with the highest coliform counts in the nutrient solution and on outer leaves of bok choy at harvest were Ebb and Flow and Drip Irrigation, respectively, which used a soilless growth substrate (peat, perlite). There were no significant differences in APC or coliform counts on the harvested bok choy among systems.

The systems with the highest coliform counts in the nutrient solution and on outer leaves of bok choy at harvest were Ebb and Flow and Drip Irrigation, respectively, which used a soilless growth substrate (peat, perlite).

Microbiota composition: There were significant differences in the microbiota composition between all systems except for the Deep Water Culture – Nutrient Film Technique systems and the Deep Water Culture – Kratky systems. All systems had a significantly different microbiota composition in fall compared to spring, with the exception of the Drip Irrigation system ($P=0.06$). This may be due to the lower sample size for Drip Irrigation system, as the run-off from the system was not available for testing in three weeks in the fall and two weeks in the spring.

Conclusion: APC and coliform counts in nutrient solution varied significantly across systems and over time. Although the differences in APC and coliform bacteria were not observed on the harvested bok choy, it is important to note that this was a small-scale study with controlled practices that may not fully reflect commercial production. Our findings highlight the need for further investigation into the role of soilless systems in contributing to differing microbial loads in hydroponic farming.

Enriching Microgreens with Iron and Zinc using Fertigation

Rishi Ravichandran, Pradip Poudel, and Francesco Di Gioia
Department of Plant Science, Pennsylvania State University

Iron (Fe) and Zinc (Zn) are two micronutrients that are essential for the proper growth and development of humans and plants and are involved in several metabolic processes. In plants, Fe is crucial for producing chlorophyll and lignin formation, while in humans, Fe is most important for energy metabolism and oxygen transport, being a key component of hemoglobin in our blood cells. Zn is crucial for DNA replication, enzyme activity, and detoxification in plants. In humans, Zn is important for reproduction, immunity, and cognition. Despite how vital Fe and Zn are for our sustained health, their deficiencies are amongst the most prevalent micronutrient deficiencies, affecting more than 1 billion people worldwide, and millions of people within the US. Depending on the severity, there can be many consequences to these deficiencies. With Zn deficiency, the biggest symptom is stunted growth in children. With Fe deficiency, most often people develop anemia, which is characterized by weakness, fatigue, and impaired mental and physical functioning. The demographics that are at highest risk of developing these deficiencies are pregnant women and children, due to their higher physiological needs, and there's an even higher prevalence in regions of Africa and Southeast Asia.

It is paramount to improve the Fe and Zn content in our food, especially in plant-based foods which contribute to a significant portion of our diet. A method that's been used to address this concern is agronomic biofortification. This strategy allows to increase the content and bioavailability of mineral nutrients, like Fe and Zn, in the edible portion of plants via agronomic methods such as fertilization. The advantage of this method is that it allows to improve the nutritional quality of the crop in a simple and quick manner, compared to other biofortification strategies such as breeding or transgenic approaches which take longer.

***Rishi Ravichandran** is a third-year PhD student in the Plant Biology graduate program at Penn State University. His research interest lies in crop improvement, specifically improving nutritional quality, or biofortification. His thesis involves researching the simultaneous biofortification of iron and zinc in microgreens using agronomic techniques.*

Vegetable crops are typically a good source of vitamins and minerals, and among vegetables, microgreens are a particularly notable source of nutrition. Microgreens are described as young, tender seedlings that are highly nutrient dense and have a very short growth cycle. They are suitable to grow for multiple crop species such as cereals and herbs, and they have low amounts of antinutritional compounds like phytic acid. They also require very few inputs for their growth and maintenance so they can adapt well to an indoor growing system, including soilless systems. All these benefits make microgreens an ideal and convenient target crop for agronomic biofortification.

Enriching plants with Fe and Zn simultaneously has shown to be a challenging effort, as these two nutrients have been known to interact antagonistically during plant uptake. This has been reported in various plant species like chickpea, rice, and maize. These two nutrients have similar ionic properties and share some of the same root transporters that allow for their uptake. At excess levels of either Fe or Zn, it's likely that there is potential competition between the two nutrients, which affects their transport into the roots and shoots. We hypothesized that if a balanced amount of Fe and Zn fertilizer was

Enriching Microgreens with Iron and Zinc using Fertigation (continued from page 34)

provided together, any potential competitive interactions could be minimized and their enrichment in the plant could be maximized. To this purpose, a study was conducted at Penn State Greenhouse facilities where the objective was to use fertigation to provide microgreens with various combinations of a selected Fe and Zn fertilizer at different concentrations. The goal was to assess the optimal combination that can allow for their simultaneous increase in the plant, without compromising plant yield and quality.

The microgreens species used were peas and sunflower, and the fertilizer sources used were iron sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$) and zinc sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$). The treatments that were applied, listed in the table below, were a factorial combination of three Fe rates (0, 20, 40 mg/L) and three Zn rates (0, 10, 20 mg/L). These treatments were prepared in half-strength Hoagland nutrient solution, and an additional treatment including standard Fe and Zn rates used in this solution was also prepared, resulting in a total of 10 treatments.

The fertigation setup was comprised of 30 NFT-like grow channels containing BioStrate-felt mats, the growing media for the microgreens, with each channel containing three replicates of each species. The Fe-Zn treatments were prepared in 14-liter buckets that contained submersible pumps which delivered the treatments to the respective grow channels via pressure-compensated emitters. After seed germination, fertigation occurred three times a day until microgreens were ready to harvest, which occurred at 9 and 10 days after seeding for sunflower and peas, respectively. At harvest, the growth parameters measured were shoot fresh weight, fresh and dry biomass, and dry matter content, and mineral analysis included measuring the Fe and Zn content (mg/kg dry weight) in the plants.

In sunflower microgreens, the Fe-Zn treatment combinations resulted in an overall decrease in the fresh yield of approximately 38%, with the Fe rate having a more significant influence than the Zn rate. At the same time, the dry biomass was relatively unaffected while the dry matter content increased. With the Fe content in the plant, the various combinations of Fe and Zn rates resulted in increased Fe accumulation, with a slight antagonism effect observed. On the other hand, for the Zn content in the plant, the

Treatment matrix		Zn (ppm) – $ZnSO_4$		
		0	10	20
Fe (ppm) – $FeSO_4$	0	Fe0-Zn0	Fe0-Zn10	Fe0-Zn20
	20	Fe20-Zn0	Fe20-Zn10	Fe20-Zn20
	40	Fe40-Zn0	Fe40-Zn10	Fe40-Zn20

Continued on next page

Efficiency, Yield, and Quality of Bok Choy Grown in Alternative Soilless Systems (continued from page 31)

> The drip irrigation system consumed the least amount of water ensuring the highest water use efficiency, while the ebb-&-flow system provided the lowest water use efficiency (Figure 2C).

the ebb-&-flow system provided the lowest water use efficiency (Figure 2C). The Kratky systems provided plants with the highest dry matter and chlorophyll content, and leaves of darker green color. Kratky systems also resulted in plants with the lowest nitrate content (Figure 2D). Instead, the Kratky and drip irrigation system, which did not require any electricity ensured the highest energy use efficiency. In conclusion, while DWC systems allowed maximizing yield, followed by the NFT systems, the Kratky system ensured the best quality and energy use efficiency, instead the drip-irrigation systems provided the highest water use efficiency.

Acknowledgements

This research was funded by the USDA-NIFA Specialty Crop Block Grants # C940001528 "Advancing the Sustainability of Indoor Urban Agricultural Systems" and # C940001096 "Employing Agronomic Biofortification Techniques for the Production of High-Value Functional Vegetable Crops".

Enriching Microgreens with Iron and Zinc using Fertigation (continued from page 35)

antagonism effect was more pronounced, where providing the Fe rates with higher Zn rates (10 and 20 mg/L) resulted in lower Zn accumulation in the plant. Overall, the combination of 40 mg/L of Fe with 20 mg/L of Zn (Fe40-Zn20) resulted in approximately 180% and 600% increase in Fe and Zn content, respectively. Sunflower microgreens fertigated with this treatment combination also result in Fe and Zn levels that contributed to 17% and 42% of the respective nutrient's recommended dietary allowance (RDA), as calculated for an adult male, marking them as "good dietary sources" for Fe and Zn.

The Fe40-Zn20 treatment combination also resulted in a dramatic increase in Fe and Zn content in pea microgreens, of about 120% and 400%, respectively. As a result, the contribution to the RDA for Fe was 25% and Zn was 35%. However, this treatment combination also resulted in a marked decrease in fresh yield of 46% and dry biomass of 35%. Overall, across both species, it was observed that fertigation using the treatment combination of 40 mg/L $FeSO_4$ and 20 mg/L $ZnSO_4$, (Fe40-Zn20), resulted in a substantial increase of both micronutrient levels. This study revealed that selecting an optimal combination of Fe and Zn application rates, the application of iron sulfate and zinc sulfate via fertigation, was effective in the simultaneous enrichment of Fe and Zn in two microgreen species. However, optimization of agronomic strategies is needed to further minimize loss in yield and quality.

Acknowledgements

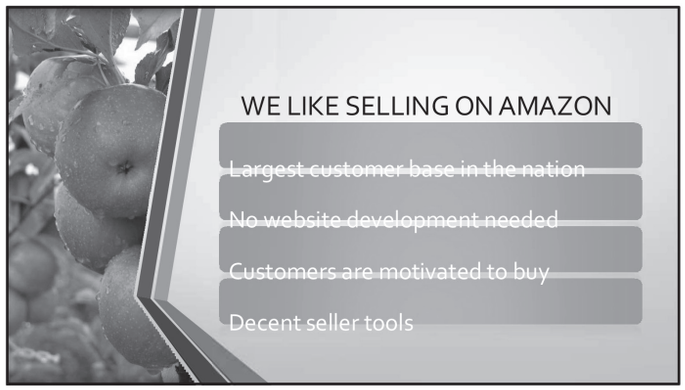
This research was funded by the USDA-NIFA Specialty Crop Block Grant "Employing Agronomic Biofortification Techniques for the Production of High-Value Functional Vegetable Crops" award agreement number: C940001096 with the support of Open Philanthropy through the grant "Food Resilience in the Face of Catastrophic Global Events".

Online Sales

Lonnie Kauffman | Kauffman Orchards

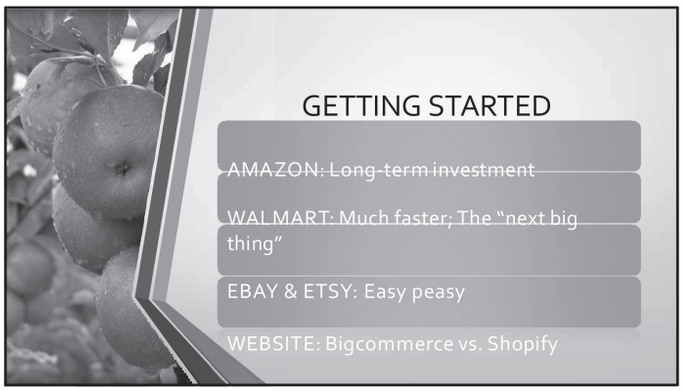
Selling online, often called “e-commerce”, is more attractive than ever for many food businesses. The American consumer is clamoring for convenience, quality, nutrition, and authenticity when one is food shopping. Many small and medium ag businesses in the mid-Atlantic are well positioned by very nature of their business to provide those components to the consumer via online sales, but how do you do it?

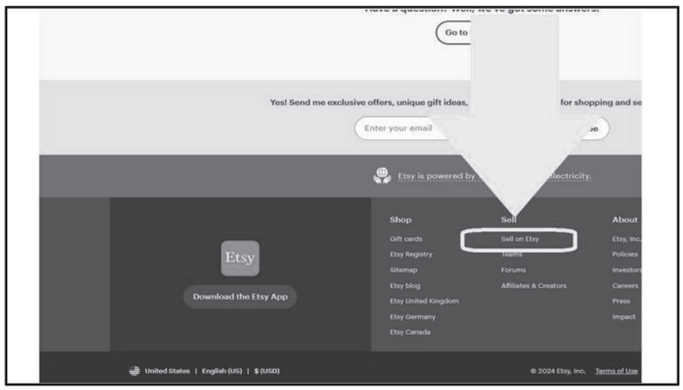
In this ecommerce presentation, we’ll discuss the “how” from the perspective of Lonnie’s 20 years of small business online food sales experience. Subjects covered will include selling perishables and shelf-stable foods; software apps that make ecommerce happen; selling on a marketplace like Amazon or Walmart vs. selling on your own branded website; and the concept of “multi-channel”.

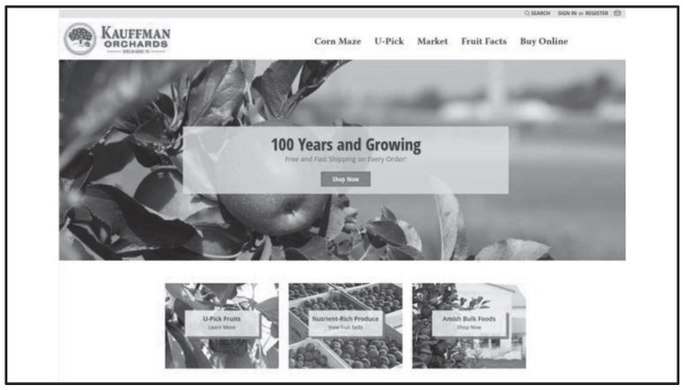


Continued on next page

Online Sales (continued from page 37)







Understanding and Managing Blossom End Rot in Vegetable Crops

Michelle Infante-Casella | Agricultural Agent/Professor
Rutgers NJAES Cooperative Extension | Gloucester County
254 County House Rd. | Clarksboro, NJ 08020
minfante@njaes.rutgers.edu | https://gloucester.njaes.rutgers.edu/ag/

Blossom end rot (BER) is a common nutritional disorder of tomato, pepper, eggplant, pumpkin, squash, and watermelon caused by a shortage of calcium (Ca) in enlarging fruits. BER can cause significant yield loss in some fruiting crops, especially tomato and pepper. It is important for vegetable growers to understand how BER develops and how to manage and prevent BER to optimize fruit development and ensure yields reach their potential.

Ca plays a major role in the functions and structure of the cell wall and membranes. Ca deficiency will result in plants with weak structures and cells that collapse. Ca enters the plant from the soil solution into root cells. Soil water is key to Ca uptake by roots. In dry soils Ca uptake is inhibited. To help increase Ca levels in plants showing deficiency after leaf tissue testing some growers will apply foliar Ca. Ca applied to the leaves is inefficient and some results have shown only about a 20% absorption rate when applied to the leaf surface. For this reason, it is most effective to have soils with optimum levels of Ca before planting. As important is to determine nutrient ratios between cations in soil that can compete for uptake with Ca, especially magnesium (Mg) levels. High concentrations of ammonium (NH_4+), potassium (K+), and magnesium (Mg++) cations in soil can all compete for uptake with Ca by plant roots. Therefore, if these nutrients are in excessive levels as compared to Ca, BER of fruit can occur.

Preventative methods to avoid BER include:

1. Soil test annually to determine Ca and Mg levels and soil pH levels.
2. Maintain soil pH in the 6.3-6.8 range.
3. Apply correct amounts of lime and fertilizer pre-plant and at the correct times to adjust pH and fertility levels to optimum.
4. Keep plants watered correctly through the entire growing season since fruit development occurs early in growth.
5. Regular, deep watering to encourage root growth and Ca uptake will reduce BER if calcium levels in the soil are adequate.
6. Avoid excessive nitrogen fertilizer application and choose nitrate (NO_3-) rather than ammonium (NH_4+) forms.

The question has been asked if different varieties are more or less susceptible to BER. Certain varieties are more susceptible to BER than others, but no varieties have shown sufficient tolerance to BER. In tomato, plum tomatoes are more susceptible to BER than other types, however most tomato types have shown BER. BER is rarely seen in cherry type tomatoes. In pepper BER can be seen more when plants have heavy fruit load. Soil fertility and soil moisture management are key to prevention of BER.

Michelle Infante-Casella *has been an Agricultural Agent and Professor, since 1996, with Rutgers Cooperative Extension, in Gloucester County, NJ. Her areas of responsibility with RCE include vegetable production and marketing as well as field crops in Gloucester County. She has a Bachelors Degree in Horticulture from Delaware Valley University and a Masters in Plant Science from Virginia Tech.*

Biofungicides for Brassica Alternaria Management - A New Hope?

Teresa Rusinek and Ethan Grundberg
Cornell Cooperative Extension | Eastern New York Commercial Horticulture Program
3357 U.S. Route 9W | Highland New York, 12528
tr28@cornell.edu and eg572@cornell.edu

Despite grower efforts to implement best cultural practices like crop rotation, production of marketable organic brassica crops is limited by Alternaria Leaf Spot (ALS)/Crown Rot. One of the obstacles that organic growers face in managing diseases like ALS is discerning which biorational fungicides and biofungicides may be effective. Although growers have been including these products in their disease management strategies, most have not observed clear results. Vegetable specialists Ethan Grundberg and Teresa Rusinek conducted a series of field trials located in the Hudson Valley, New York to address gaps in organic management of brassica diseases. After three years of applied field research that began in 2020, the researchers have come to the following conclusions:

Teresa Rusinek *is a regional vegetable specialist with the Eastern NY Commercial Horticulture Program. She works with vegetable growers across the Hudson Valley Region. Her responsibilities include providing on-farm consultations to growers on production issues in field and protected agriculture. Teresa focuses her extension and applied research efforts in Integrated pest management; Biocontrols/ biorationals; and Horticulture.*

Ethan Grundberg *(MS '09, University of California, Davis) is a regional vegetable specialist with Cornell Cooperative Extension's Eastern New York Commercial Horticulture Program. Grundberg serves the commercial vegetable growers of eastern New York with a specific emphasis on providing technical support to Orange County's black dirt onion farms. Grundberg brings a practical perspective to applied research having managed vegetable farms in both Massachusetts and California prior to joining extension. His research interests include evaluating biofungicides in both organic and conventional systems, evaluating small farm equipment, improving onion pest management through adjuvant selection, and improving management of the allium leafminer.*

Key Findings:

- Programs with Oso (polyoxin D zinc salt, Certis USA) at 6.5 fl oz/ac significantly reduced ALS severity and increased marketable broccoli yield
- Reducing biofungicide/biorational applications from 7 on a weekly schedule over the full production period to 3 or 5 later in the production cycle did not result in decreased control in 2022 (dry year) when using Oso
- Rotate Oso with Badge X2 (1.8 lbs./ac) or a tank mix of Stargus (3 qt/ac) + Regalia (2 qt/ac) for resistance management
- Reducing biofungicide/biorational applications can reduce costs without sacrificing ALS control on foliage or crowns
- Rotating Oso applications with a Stargus + Regalia tank mix can reduce or eliminate copper fungicide applications

Results from a 2020 screening trial supported what both private industry and researchers have

Biofungicides for Brassica Alternaria Management - A New Hope? (continued from page 40)

concluded about managing other diseases with biorationals and biofungicides: biorationals and biofungicides alone are typically insufficient to manage intense disease pressure, especially difficult to control pathogens like those that cause ALS. Instead, more researchers and growers are experiencing greater success managing plant diseases with biorationals and biofungicides by using those products in rotation with more aggressive chemistries and as tank-mix companions to other products. Analysis of data collected in the 2020 trials in the Hudson Valley revealed trends toward lower disease severity in plots treated with Badge X2, Regalia, Stargus, and Double Nickel. Those products were included in the 2021 Hudson Valley trial programs along with several newly released OMRI-listed biorational products, including Theia (*Bacillus subtilus* strain AFS032321), Howler (*Pseudomonas chlororaphis* strain AFS009), and Oso (polyoxin D zinc salt). A total of 22 biorational programs that rotated through different chemistries and tank-mixing compatible products were evaluated in 2021 with the goal of collecting data to help inform and develop more robust season-long bio-rational programs. Oso had the lowest numerical area under the disease progress curve (AUDPC) ratings and was among the highest in marketable yield in the 2021 trial. Similar results were reported from a 2021 trial in Geneva NY, led by Cornell pathologist Dr. Chris Smart. The focus in year three of this project was on evaluating programs consisting of weekly fungicide applications beginning after transplant built on best performers from 2020 and 2021 while following best resistance management practices. Programs were designed using the lower rate of Oso at 6.5 fl oz/acre either alternating or in tank mix combinations with other products. We examined the efficacy of several reduced fungicide application programs that further reduce costs and copper fungicide applications. A comprehensive list of treatments and rates follows:

Treatment	Products and Rates*
A	UTC (water and Attach at 0.125% v/v dilution)
B	Badge X2 @ 1.35 lbs./acre
C	Oso @ 6.5 fl oz/acre
D	Badge X2 @ 1.35 lbs./acre PLUS Oso @ 6.5 fl oz/acre
E	Badge X2 @ 1.35 lb./acre PLUS Regalia @ 2 qt/acre
F	Badge X2 @ 1.35 lbs./acre PLUS EcoSwing @ 32 fl oz/acre
G	Badge X2 @ 1.80 lbs./acre weeks 1,2,3,5
H	Badge X2 @ 1.8 lbs./acre weeks 1,2,3,5; Oso @ 6.5 fl oz/acre weeks 4,6,7
I	Carb-0-Nator @ 5 lbs./100 gal weeks 1,2,3,5; Oso @ 6.5 fl oz/acre weeks 4,6,7
J	Badge X2 @ 1.8 lbs./acre weeks 1,2,3,5; EcoSwing @ 32 fl oz/acre weeks 4,6,7
K	Badge X2 @ 1.80 lbs./acre PLUS Regalia @ 2 qt/acre weeks 1,2,3,5
L	Badge X2 @ 1.80 lbs./acre PLUS Regalia @ 2 qt/acre weeks 1,2,3,5; Stargus@ 3 qt/acre weeks 4,6,7
M	Badge X2 @ 1.80 lbs./acre PLUS Regalia @ 2 qt/acre weeks 1,2,3,5; Oso @ 6.5 fl oz/acre weeks 4,6, 7
N	Regalia @ 2 qt/acre PLUS Stargus @ 3 qt/acre weeks 1,2,3,5; Oso @ 6.5fl oz/acre weeks 4,6,7
0	Badge X2 @ 1.80 lbs./acre weeks 3,5; Badge X2 @ 1.80 lbs./acre PLUS Oso @ 6.5 fl oz/acre weeks 4,6, 7
p	Badge X2 @ 1.80 lbs./acre week 5; Badge X2 @ 1.80 lbs./acre PLUS Oso @ 6.5 fl oz/acre weeks 6,7

* All treatments included Attach at 0.125% v/v dilution

Continued on next page

Biofungicides for Brassica Alternaria Management - A New Hope? (continued from page 41)

Results from 2022 Best Performers Programs:

	AUDPC	Marketable Yield (lbs.)	Percent Marketable Yield	Crown Disese Severity %
A-UTC	279.92 a	1.09 de	15.78 cd	35.4 a
B-Badge	126.03 bcde	3.55 bcde	49.89 abcd	5.0 abc
C-Oso	108.19 de	6.7 ab	88.10 a	0.63 c
D-Badge+Oso	117.26 cde	5.65 abc	73.47 ab	2.5 bc
E-Regalia+Badge	224.29 ab	4.01 abcde	60.07 abc	7.03 abc
F-Badge+EcoSwing	204.21 abc	3.76 abcde	49.8 abcd	7.4 ab
G-Badge (wks 1,2,3,5)	209.17 ab	0.51 e	7.57 d	23.13 a
H-Badge (wks 1,2,3,5)-Oso (wks 4,6, 7)	106.96 de	4.7 abcde	60.00 abc	3.33 abc
I-Carb-O-Nator (wks 1,2,3,5) Oso (wks 4,6, 7)	147.21 abcde	5.04 abcd	63.28 abc	5.75 abc
J-Badge (wks 1,2,3,5) EcoSwing (wks 4,6, 7)	163.88 abcd	1.12 de	15.85 cd	17.43 ab
K-Regalia+Badge (wks 1,2,3,5)	196.94 abc	1.47 cde	22.64 cd	18.83 ab
L-Regalia+Badge (wks 1,2,3,5) Stargus (wks 4,6,7)	182.61 abc	1.95 cde	25.32 bcd	18.4 ab
M-Regalia+Badge (wks 1,2,3,5) Oso (wks 4,6,7)	179.43 abc	4.53 abcde	58.75 abc	4.48 abc
N-Regalia+Stargus (wks 1,2,3,5) Oso (wks 4,6,7)	100.26 de	7.96 a	88.44 a	1.55 c
0-Badge (wks 3,5)-Badge+Oso (wks 4,6,7)	91.38 e	6.7 ab	91.72 a	0.83 c
P-Badge (wk 5), Badge+Oso (wks 6,7)	113.85 cde	6.51 ab	88.87 a	1.35 bc
p value	0.00404	<0.0001	<0.0001	<0.0001

[v] Numbers within each column followed by the same letter are not significantly different from each other based on Tukey's HSD at p = 0.05
[w] Area under the disease progress curve (AUDPC) was calculated from August 19 to September according to the formula: $\Sigma n\ i=1[(Ri+1 + Ri)/2][ti+1 - ti]$, where R = disease severity rating (% of leaf surface affected) at the ith observation, ti = time (days) since the previous rating at the ith observation, and n = total number of observations. Values were calculated based on the average percent disease severity across the plot. [x] Harvest weight was recorded on September 29 and 30, representing the total weight of 10 heads.

2023 Adjuvant Trial:

Brassica crops have waxy plant tissues that repel water-based solutions making effective foliar pesticide applications challenging. In such cases, adjuvants are often used to improve deposition onto plant surfaces therefore enhancing the effectiveness of a pesticide. In 2023, Rusinek and Grundberg conducted a study to evaluate the impact of the adjuvants Attach at a 0.125% v/v dilution rate and OROBOOST at a 0.25% v/v dilution rate on the performance of the biofungicide Oso. Attach (Pinene Polymers) is a non-ionic spreader sticker. OROBOOST (Alcohol Ethoxylate) is a non-ionic surfactant spreader,

Continued on page 46

Managing Allium Leafminer with OMRI-listed Insecticides

Teresa Rusinek and Ethan Grundberg
Vegetable Specialists | Cornell Cooperative Extension Eastern NY Commercial Horticulture Program
3357 U.S. Route 9W | Highland New York, 12528
tr28@cornell.edu and eg572@cornell.edu

The invasive fly pest, allium leafminer (*Phytomyza gymnostoma*), has been established in the Northeast since 2016 and has caused widespread crop damage in New York, Massachusetts, Rhode Island, Pennsylvania, New Jersey, Maryland, and Delaware. In research trials, the fall flight has caused damage to over 98% of leeks and scallions that were not covered or managed with insecticides. Rusinek and Grundberg have conducted field research trials for eight years with the goal of identifying effective management strategies for organic farms to use to reduce allium leafminer (ALM) damage. Effective management tactics can include installing exclusion netting or row cover for the duration of the ALM flight, using reflective metalized plastic mulch, and making carefully timed applications of OMRI-listed insecticides mixed with specific adjuvants to enhance their performance.

Lifecycle: There are two generations of ALM each season. The spring flight typically begins in mid-April and continues through late May. While damage to crops is possible during the spring flight, ALM pressure is generally lower in the spring than in the fall. We do not have accurate phenology models to allow us to predict the emergence of the fall flight but fall ALM adult activity has begun in early-to-mid-September the past eight years in the Hudson Valley of NY (Sep 19, 2017, Sep 11, 2018, Sep 9, 2019, Sep 8, 2020, Sep 3, 2021, Sep 12, 2022, Sep 6, 2023, and Sep 9, 2024). Adults are active for approximately 7 weeks, or through the end of October. Emerged adults create the diagnostic line of oviposition puncture marks on allium leaves during feeding and egg-laying. Larvae that hatch from eggs eat their way down the inside of the leaves toward the bulbs opening physical wounds where soft rot pathogens often enter. The larvae then pupate either inside the bulb and stem or in the soil around the plants for the winter and early spring until adults emerge in the spring.

Teresa Rusinek *is a regional vegetable specialist with the Eastern NY Commercial Horticulture Program. She works with vegetable growers across the Hudson Valley Region. Her responsibilities include providing on-farm consultations to growers on production issues in field and protected agriculture. Teresa focuses her extension and applied research efforts in Integrated pest management; Biocontrols/ biorationals; and Horticulture.*

Ethan Grundberg *(MS '09, University of California, Davis) is a regional vegetable specialist with Cornell Cooperative Extension's Eastern New York Commercial Horticulture Program. Grundberg serves the commercial vegetable growers of eastern New York with a specific emphasis on providing technical support to Orange County's black dirt onion farms. Grundberg brings a practical perspective to applied research having managed vegetable farms in both Massachusetts and California prior to joining extension. His research interests include evaluating biofungicides in both organic and conventional systems, evaluating small farm equipment, improving onion pest management through adjuvant selection, and improving management of the allium leafminer.*

Continued on next page

Managing Allium Leafminer with OMRI-listed Insecticides (continued from page 43)

> The working theory emerging from that trial data is that aggressive sticker type adjuvants like NuFilm P may interfere with the translaminar activity of the spinosad preventing it from reaching the ALM larvae inside the leaf tissue.

Damage: Since there are typically fewer cultivated and wild alliums in the environment in the fall, growers in Pennsylvania and New York have experienced a "concentration effect" with their fall-grown alliums. Leeks that were not treated with insecticides averaged over 40 maggots and pupae per plant, with a high of 160, in research trials in the fall of 2020. Much smaller populations of allium leafminer can still be problematic, causing cosmetic damage to scallion foliage and opening physical wounds in leeks where soft rot bacteria can ruin the crop.

Cultural Controls:

Row Covers and Exclusion Netting:

Physically excluding adult ALM flies from host crops is the most effective strategy that organic growers can use to reduce crop damage. Growers relying on row cover to exclude adult flies from host crops should install the covers before the flight begins, or around September 1 in the Northeast. Field trials funded by Northeast SARE in 2020-21 demonstrated that waiting until two weeks after the fall flight had begun to cover leeks resulted in much higher densities of ALM larvae and pupae in the plants and significant crop loss. Growers have had success using insect netting, like Protek-Net, to reduce the risk of heat stress associated with spun bond covers. Both spun bond row cover and insect netting must be well-anchored to prevent gaps between the ground and the crop to be effective. Metal support hoops should be used to avoid physically constraining crop growth and development; placing row cover directly on the crop has resulted in severely curved leeks that growers have found challenging to sell.

Metalized Reflective Plastic Mulch:

Rusinek and Grundberg have also found that ALM severity is reduced by about 33% in both spring and fall scallions and well as fall leeks when those alliums are planted on reflective plastic mulch compared to either black or white plastic. However, unsprayed fall leeks on reflective mulch in 2019 still had, on average, over 30 ALM maggots and pupae per plant, so using reflective mulch alone does not provide sufficient suppression. Rusinek and Grundberg have found that combining reflective plastic mulch with carefully timed OMRI-listed insecticide applications (see chemical controls below) has resulted in up to a 92% reduction in the number of ALM maggots and pupae in leeks compared to unsprayed leeks on white plastic mulch.

Chemical Controls:

Application Timing

Multiple years of research confirmed that the critical window for using insecticides for managing ALM in the fall begins two weeks after the beginning of the flight. While conventional growers have had some success making just two applications of systemic chemistries (Exirel, Scorpion) two and four weeks after the start of the flight, field trials have found that three applications of OMRI-listed insecticides 7-to-10 days apart are necessary to reduce ALM damage to acceptable levels.

Effective Products

The most effective OMRI-listed insecticide for ALM management in field trials has

Managing Allium Leafminer with OMRI-listed Insecticides (continued from page 44)

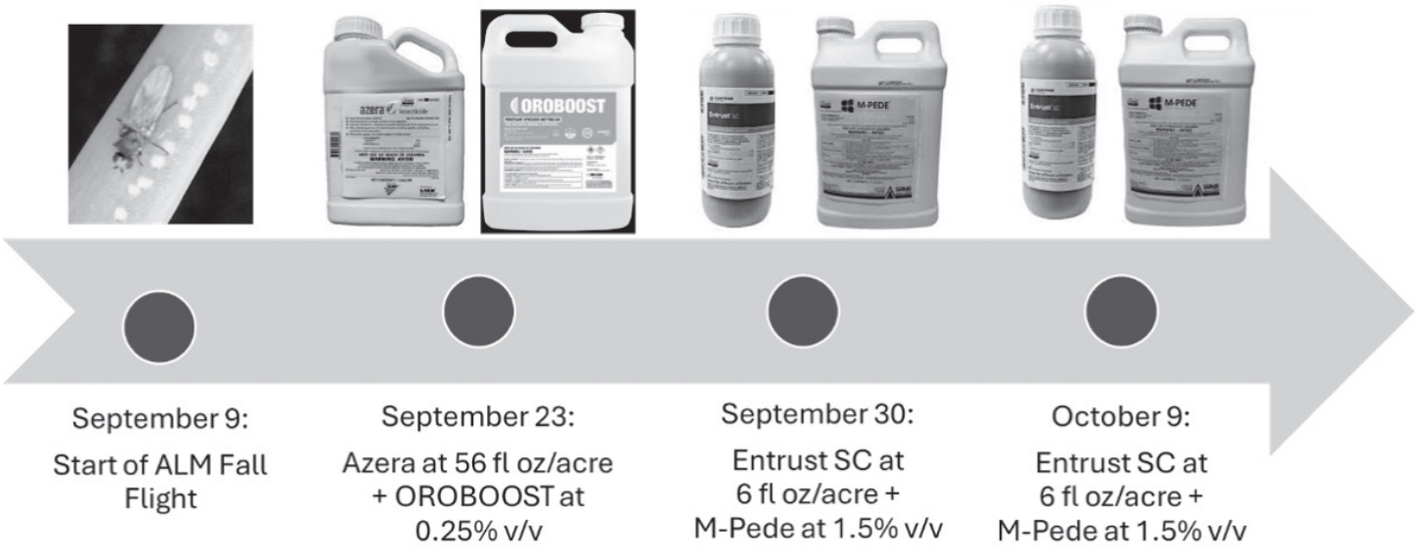
consistently been Entrust SC (spinosad) at 6 fl oz/acre. However, growers are restricted to just two sequential applications of Entrust SC before the label mandates the use of a product with a different mode of action. Research in NY has shown that **starting a spray program with a single application of Azera (pyrethrins+azadirachtin) at 56 fl oz/acre two weeks after the start of the flight followed by two sequential applications of Entrust SC on a 7-10 day interval afterward has been the most effective OMRI-listed insecticide program to reduce ALM damage.** Unfortunately, Azera is no longer readily available for purchase. However, growers can combine a pyrethrins product (PyGanic 5.0) with any number of azadirachtin products (AzaGuard, Neemix, OLF) as a tank mix for a comparable combination of chemistries.

Adjuvant Pairing

The active ingredient in Entrust SC, spinosad, is translaminar, which means that it can move through the waxy cuticle surrounding the leaf into the leaf tissue itself. Research completed by Cornell University entomologist Dr. Brian Nault found that co-applying Entrust SC with the sticker adjuvant NuFilm P resulted in an increase in ALM damage compared to applying Entrust SC without any adjuvant. The working theory emerging from that trial data is that aggressive sticker type adjuvants like NuFilm P may interfere with the translaminar activity of the spinosad preventing it from reaching the ALM larvae inside the leaf tissue. After evaluating several alternative OMRI-listed adjuvants, Rusinek and Grundberg have found that **combining the two applications of Entrust SC with a 1%-1.5% v/v solution of M-Pede (potassium salts of fatty acids) or other similar labeled insecticidal soaps has been the most effective at enhancing the performance of the spinosad.**

However, insecticidal soaps have a high pH and can push tank mix solutions well into the 8.0 to 8.5 range. The efficacy of the active ingredient pyrethrins is negatively impacted by solution pHs above 7.0. Therefore, **it is imperative that growers NOT use M-Pede or other insecticidal soaps in combination with a pyrethrins/azadirachtin tank mix. Instead, research has found that OMRI-listed penetrant**

Recommended 2024 Spray Program



Continued on next page

Biofungicides for Brassica Alternaria Management - A New Hope? (continued from page 42)

penetrant, and wetting agent. Oso alone and Oso plus adjuvant fungicide programs were evaluated for their control of ALS in an organically managed field of 'Emerald Crown' broccoli. Treatments were applied a total of 8 times on a weekly basis starting in August. Rainfall during this period was above average contributing to high ALS pressure and crown disease severity. Results from this trial suggest that the OMRI-listed adjuvants Attach and OROBOOST may have some impact in reducing the severity of brassica Alternaria in broccoli, but the differences between Oso alone and Oso plus adjuvant treatments were not statistically significant.

Managing Allium Leafminer with OMRI-listed Insecticides (continued from page 45)

type adjuvants, such as OROBOOST at a 0.25% v/v concentration, have enhanced the efficacy of the pyrethrins/azadirachtin tank mix and maintained and maintained an acceptable solution pH.

Entrust SC Rate Response Research

Growers have also repeatedly asked whether a lower rate than 6 fl oz/acre of Entrust SC may also be effective at reducing damage from ALM. Field trials in 2023 and 2024 evaluated the effect of using the lowest labeled rate of Entrust SC, 3 fl oz/acre, compared to the 6 fl oz/acre rate on ALM damage in fall scallions. While the 3 fl oz/acre rate did result in a decrease in ALM damage compared to the unsprayed control, scallions in the plots treated with 6 fl oz/acre had significantly less damage. Therefore, it is recommended to use the highest labeled rate of Entrust SC at 6 fl oz/acre for the best results.

Recommended OMRI-listed Insecticide Program

Two weeks after the start of the fall ALM flight, growers should spray Azera at 56 fl oz/acre or a pyrethrins/azadirachtin tank mix (rates will vary by product) in combination with the adjuvant OROBOOST at a 0.25% v/v concentration. 7 to 10 days later, the first application of Entrust SC at 6 fl oz/acre co-applied with a 1%-1.5% v/v solution of M-Pede is made, followed by a second application of the same Entrust SC + M-Pede tank mix 7 to 10 days later.

> However, insecticidal soaps have a high pH and can push tank mix solutions well into the 8.0 to 8.5 range. The efficacy of the active ingredient pyrethrins is negatively impacted by solution pHs above 7.0.

Realistic Expectations

Physically excluding adult ALM from host crops is still, by far, the most effective strategy for reducing ALM damage in fall alliums. Field trials in 2024 evaluating the recommended program described above still found that treated scallions still contained an average of over 3.3 ALM larvae and pupae per plant and 58% of the scallions had more than 2 ALM larvae and pupae inside. Properly installed row covers with support hoops left on for the duration of the fall flight have yielded 100% marketable leeks in trials. The cost of three insecticide applications to manage ALM may not be justified for smaller allium plantings where row covers or insect exclusion netting can be effectively managed.

Can OMRI-listed herbicides take the place of flame weeding in carrots?

Ethan Grundberg
Vegetable Specialist | Cornell Cooperative Extension Eastern NY Commercial Horticulture Program
150 Downs St. | Kingston, NY 12401
eg572@cornell.edu

Summary

Pre-crop emergent applications of Axxe and Homeplate are as effective as pre-crop emergent flame weeding at reducing weed pressure in organic carrot production. Unfortunately, neither tactic is very effective at managing grasses. Shielded between row applications of Axxe and Homeplate are effective at managing broadleaf weeds, but there is a very high risk of unacceptable crop injury from this strategy. The potential efficiency gain of using a pre-crop emergent herbicide application in place of thermal weeding makes the weed management strategy cost competitive and can increase the likelihood of executing the strategy during the narrow ideal window of opportunity just before the carrots push through the soil. While more research is needed on the effects of pH buffers and adjuvants on the efficacy of Homeplate and Axxe, trials and grower experience suggest that using an adjuvant like Attach or ORO RZ along with a citric acid acidifier like Attitude or LeafLife can improve weed control when using these OMRI-listed herbicides.

Ethan Grundberg *(MS '09, University of California, Davis) is a regional vegetable specialist with Cornell Cooperative Extension's Eastern New York Commercial Horticulture Program. Grundberg serves the commercial vegetable growers of eastern New York with a specific emphasis on providing technical support to Orange County's black dirt onion farms. Grundberg brings a practical perspective to applied research having managed vegetable farms in both Massachusetts and California prior to joining extension. His research interests include evaluating biofungicides in both organic and conventional systems, evaluating small farm equipment, improving onion pest management through adjuvant selection, and improving management of the allium leafminer.*

Discussion

Weed control is commonly cited by growers as the most significant challenge to carrot production in the Northeast. Organic carrot growers depend on multiple weed management tactics to achieve acceptable control, including pre-plant stale seedbedding, thermal or flame weeding prior to crop emergence, mechanical cultivation with Buddingh baskets and newer precision tools, and hand weeding. These approaches are often inadequate, especially in controlling grasses, and require a significant number of labor-hours to implement. However, two OMRI-listed herbicides have become available to specialty crop growers in the past few years that show promise for expanding the integrated weed management toolbox for organic carrot growers. Axxe (ammonium nonanoate) is a non-selective broad-spectrum herbicide manufactured by BioSafe Systems that destroys the cell walls of plant tissue that it contacts, resulting in rapid burndown. Homeplate (caprylic and capric acids) is also a non-selective herbicide manufactured by Certis that dissolves the waxy cuticle protecting leaves and destroys the cell walls of plant tissue that it contacts.

Continued on next page

Can OMRI-listed herbicides take the place of flame weeding in carrots? (continued from page 47)

Research completed in 2021 and 2022 was designed to answer the following questions:

1. Can a single pre-crop emergent application of an OMRI-listed herbicide be used to improve annual grass control when compared to pre-crop emergent flame weeding?
2. Can multiple post-emergent shielded applications of an OMRI-listed herbicide improve annual grass and broadleaf control when compared to mechanical cultivation?
3. How cost effective are newer OMRI-listed herbicides?
4. Can the performance of Homeplate be improved by adding acidifiers and surfactants to the spray tank?

Questions 1-3 were studied in 2021 field trials that were conducted with the cooperation of Tyler Dennis at Alewife Farm in Kingston, NY on Unadilla silt loam in a commercial planting of organically managed 'Bolero' storage carrots. Carrots were direct seeded on June 25, 2021 by the farm owner Tyler Dennis using a Jang JPH-4 seeder into 5-foot wide beds with 3 rows of crop approximately 12-inches apart. Dry conditions at planting prolonged germination; first carrot emergence was observed on July 5. The primary weed species in the trial plots was crabgrass (*Digitaria sanguinalis*). The treatments included in the 2021 field trials were:

A. **"Grower Standard":** Pre-crop emergent thermal weeding on July 6 followed by multiple passes with a basket weeder.

B. **Axxe Pre-Crop Emergent:** Pre-crop emergent broadcast application of an 8% v/v dilution of Axxe co-applied with Attach at 40 gallons per acre on July 6 followed by multiple passes with a basket weeder.

C. **Homeplate Pre-Crop Emergent:** Pre-crop emergent broadcast application of a 6% v/v dilution of Homeplate co-applied with Attach at 40 gallons per acre on July 6 followed by multiple passes with a basket weeder.

D. **Axxe Shielded:** Same as treatment B, then followed by three shielded applications of Axxe at an 8% v/v dilution co-applied with Attach at approximately 60 gallons per acre on July 16, July 27, and August 5 instead of the mechanical cultivation passes.

E. **Homeplate Shielded:** Same as treatment C, then followed by three shielded applications of a 6% v/v dilution of Homeplate co-applied with Attach at approximately 60 gallons per acre on July 16, July 27, and August 5 instead of the mechanical cultivation passes.

F. **Hand-Weeded Check:** Same as treatment A, then followed by three thorough hand-weeding events on July 27, August 5, and August 30 for a total of approximately 299.48 hours per acre of weeding labor.

1. *Can a single pre-crop emergent application of an OMRI-listed herbicide be used to improve annual grass control when compared to pre-crop emergent flame weeding?*

No. Unfortunately, the results from the 2021 trial do not suggest that pre-crop emergent herbicide applications are more effective than pre-crop emergent thermal weeding at reducing either the average number of grasses or the aboveground fresh weed weight of grasses. However, there was no significant difference in either grass weed density or broadleaf weed density between the pre-crop emergent herbicide treatment and the pre-crop emergent flame weeding. Therefore, **a single broadcast application of either Axxe or Homeplate pre-crop emergent can provide a comparable level of overall weed control to that achieved by pre-crop emergent thermal weeding.**

2. *Can multiple post-emergent shielded applications of an OMRI-listed herbicide improve annual grass and broadleaf control when compared to mechanical cultivation?*

No. Neither of the shielded herbicide application treatments was more effective at reducing the total number of weeds or the aboveground fresh

Can OMRI-listed herbicides take the place of flame weeding in carrots? (continued from page 48)

weight of weeds when compared to treatments incorporating mechanical cultivation. However, **shielded applications of both Axxe and Homeplate were more effective at reducing the number of broadleaf weeds in the research plots compared to treatments relying on mechanical cultivation, but failed to suppress crabgrass.** Unfortunately, shielded applications of contact burndown herbicides like Axxe and Homeplate pose a significant risk of crop injury to crops like carrots with low-growing architectures. In order to achieve adequate coverage on the weeds to maximize the burn down effect of Axxe and Homeplate, the researcher used turbo twinjet nozzles between the shields. The nozzles did provide excellent coverage in the between row target deposition area, but also tended to produce droplets that were carried underneath the small gap between the soil and the shields. The drift under the shields caused a significant reduction in crop stand and, ultimately, crop yield.

3. *How cost effective are newer OMRI-listed herbicides?*

Based on the cost of production data provided by Tyler Dennis in 2021, **there was no statistically significant difference in estimated revenue per acre between the grower standard treatment and the two pre-crop emergent herbicide application treatments in the 2021 field trials. This finding combined with the efficacy data presented above supports the conclusion that a single pre-crop emergent application of either Axxe or Homeplate could be a viable replacement for pre-crop emergent thermal weeding in organic carrot production.** The impact of using herbicides in place of flame weeding on farm revenue is highly dependent on scale and the equipment being used for both herbicide applications and for thermal weeding. The grower-cooperator noted, "I have a 1 bed flame weeder that I need to drive around 1 mph to be effective and I have a boom sprayer that covers 5 beds at a time going about 2.5 mph. Also, the propane tanks on the flamer freeze up and have to thaw out about once per acre which is a 30-to-40-minute stop." Tyler can complete his time sensitive pre-crop emergent herbicide application over 10 times faster than he is able to complete thermal weeding on the same area.

4. *Can the performance of Homeplate be improved by adding acidifiers and surfactants to the spray tank?*

Yes! Question 4 was evaluated in a 2022 trial at Alewife Farm in a fallow field with Unadilla silt loam soil. The field was disced on 30 June then tilled again with an Unverferth Perfecta field cultivator on 11 July. Each 6-foot wide by 10-foot long plot in the fallow field was flagged on 25 July and was separated from adjacent plots by a 5-foot buffer strip. Treatments were applied in the randomized complete block design (RCBD) trial with 5 replications on 8 August when broadleaf weeds in the field were approximately 4-inches tall. Applications were made using a CO_2–pressurized backpack sprayer and boom equipped with four, twin turbojet nozzles (TTJ60-8003VS) spaced 15" apart and calibrated to deliver 51 gallons per acre at 40 PSI. **The results of the trial suggest that using an adjuvant such as ORO RZ in addition to a citric acid pH buffer can improve the efficacy of Homeplate in reducing weed densities, especially broadleaf weeds.** While other adjuvants were not evaluated in this trial, growers have observed that products like Loveland's Attach have also improved the performance of Homeplate. The manufacturer of Axxe, Biosafe Systems, states that their product does not require the addition of an adjuvant, so only Homeplate was included in this trial.

Organic Late Blight Tomato Cultivar Evaluation

Elsa Sánchez and Tom Butzler, Penn State Extension

In 2024, we evaluated indeterminate and determinate late blight-resistant slicing tomato cultivars using organic practices at Penn State University's Russel E. Larson Agriculture Research Center in Pennsylvania Furnace to provide farmers with up-to-date information for successful late blight-resistant cultivar selection based on yield.

Methods. The study was conducted in central Pennsylvania at Pennsylvania State University's Russell E. Larson Agricultural Research Center in Pennsylvania Furnace in a field managed using synthetic fertilizers and pesticides before 2024.

The project consisted of two experiments, one evaluating seven indeterminate cultivars and the other six determinate cultivars (Table 1). For both experiments, four-week-old transplants were planted on June 5th, 2024, into a plasticulture system consisting of raised beds and two lines of drip irrigation tape covered with embossed black plastic mulch; one line was used for irrigation and the other for fertigation. Plots consisted of 6 plants planted with 1.5 ft in-row spacing and 10 ft between rows. Plants were provided with 1-1.5 acre-inches of water each week. Before pulling beds, organic granular fertilizer (Fertrell Blue N 5-1-1) was applied at a rate of 150 lb/acre N. Additionally, the planting was fertigated weekly with 2 lb/acre N of organic liquid fertilizer (Alaska Fish Emulsion 5-1-1). Diseases were managed with Kocide 3000-O; 2 lb/acre), applied weekly, beginning September 3rd. Weeds were suppressed by planting a cover crop of annual ryegrass, at a rate of 25 lb/acre, between planting rows and surrounding the field. Plants were trained vertically using a Florida Weave system with 1-inch square wooden stakes placed in the following pattern: plant, plant, stake, plant, plant, stake, etc. The first string was placed when plants were about 10 inches tall. Stings were placed twice more in the determinate experiment and thrice more in the indeterminate experiment.

Tom Butzler *is a Horticulture Extension Educator in central Pennsylvania. Tom has worked for over 28 years with Cooperative Extension in North Carolina and Pennsylvania. During his career he has worked intensively with vegetable growers, landscape and turf professionals and area farmers with their production and pest management issues. Tom has a B.S. degree in Horticulture from The Pennsylvania State University and a MS in Plant Pathology from North Carolina State University.*

Tomatoes were harvested weekly when they reached red maturity, starting on August 2nd, 2024, and ending on October 3rd, 2024. Immediately after harvesting, the tomatoes were categorized as marketable or unmarketable, counted, and weighed. Additionally, marketable tomatoes were sized as small (< 2 inches in diameter), medium (2 – 2.75 inches in diameter), large (2.75 – 3.5 inches in diameter), or extra-large (> 3.5 inches in diameter).

A randomized complete block design was used for both experiments, and each cultivar was replicated four times. Data was collected from 6 plants per cultivar per replication and analyzed using the mixed procedure with means separated using pdiff.

Discussion. To confirm our results are repeatable, we need to conduct the study again. The results and this discussion should be viewed as preliminary.

We did not observe any incidence of Late Blight in either experiment.

Indeterminate Evaluation. 'Mountain Rouge' was used as the standard.

Organic Late Blight Tomato Cultivar Evaluation (continued from page 50)

Table 1. Indeterminate and determinate Late Blight-resistant cultivars evaluated in an organic production system in Pennsylvania Furnace, Pennsylvania, at Pennsylvania State University's Russell E. Larson Agricultural Research Center in 2024.

Tomato type	Cultivar	Notes	Seed source
Indeterminate	Abigail	Heirloom-type; pink at maturity; minimal fruit cracking and stem scarring; large-sized fruit (10-16)	Johnny's Selected Seeds (Winslow, ME)
	Big Beef	All-America Selection Winner; red at maturity; resistance to several other diseases and nematodes; large-sized fruit (10-12 oz)	Johnny's Selected Seeds
	Beef Maestro	Heirloom-type; red at maturity; large-sized fruit (≥13 oz)	Totally Tomatoes (Randolph, WI)
Determinate	Damsel	Pink at maturity; resistance to Verticillium Wilt and nematodes; medium-sized fruit (8-12 oz)	Johnny's Selected Seeds
	Rose de Berne	Heirloom; pink at maturity; resists cracking; medium-sized fruit (4-8 oz)	High Mowing Organic Seeds (Wolcott, VT)
	Strawberry Fields	Heirloom-type; red at maturity; tolerance to blossom end rot and shoulder cracking; medium-sized fruit (7-10 oz)	Johnny's Selected Seeds
	Mountain Rouge	All-America Selection Winner; pink at maturity; resistance to nematodes; large-sized fruit (12-14 oz)	Totally Tomatoes
	Defiant	Red at maturity; resistance to Early Blight; medium-sized fruit (8-12 oz)	Johnny's Selected Seeds
	Galahad	All-America Selection Regional Winner; red at maturity; resistant to several other diseases and nematodes; medium-sized fruit (7-12 oz)	Johnny's Selected Seeds
	Iron Lady	Red maturity; resistance to several other diseases; medium-sized fruit (about 5 oz)	High Mowing Organic Seeds
	Mountain Gem	Red at maturity; resistance to Tomato Mosaic Virus; medium-sized fruit (6-8 oz)	Totally Tomatoes
	Mountain Merit	All-American Selection Regional Winner; red at maturity; resistant to several other diseases and nematodes; medium-sized fruit (8-10 oz)	Johnny's Selected Seeds
	Stellar	Red at maturity; intermediate resistance to Early Blight and Septoria Leaf Spot; medium-sized fruit (5-7 oz)	Totally Tomatoes

Continued on next page

Organic Late Blight Tomato Cultivar Evaluation (continued from page 51)

We observed unmarketable tomatoes to be widespread across most cultivars. Specifically, six out of the seven indeterminate cultivars produced higher unmarketable yields by weight compared to marketable ones, while five out of the six determinate cultivars also yielded more unmarketable than marketable tomatoes by weight. Fruit with large blossom end scarring, blossom end rot, and tomato pox were culled. The greatest cause of culled fruit was concentric and radial cracking and rain check. We have observed an increase in water-related disorders, where a hot, dry start to the season led to issues such as blossom end rot, followed by early fall rain events that became more extreme and frequent, resulting in higher rates of concentric and radial cracking and rain check. For example, in June, the average temperature was 70.5°F, compared to the historical norm of 68.1°F, and rainfall was only 2.58 inches, significantly below the historical average of 4.09 inches. July also followed this pattern, with an average temperature of 74.7°F (compared to a normal 72.2°F) and total precipitation of 2.41 inches versus the typical 3.79 inches. This hotter, drier summer contributed to early-season disorders. In August, temperatures stabilized at the historical average of 70.5°F, but rainfall surged to 6.03 inches, well above the historical 4.16 inches, intensifying water-related disorders in the later part of the season.

'Abigail,' an heirloom-style pink cultivar, with blossom-end scarring (right), is a contributing factor to the unmarketable tomatoes in this trial.

Photo: Tom Butzler

The mean unmarketable yield per plant exceeded the mean marketable yield for 'Rose de Berne', 'Damsel', 'Mountain Rouge', and 'Abigail' by number and 'Damsel', 'Mountain Rouge', and 'Abigail' by weight. Seed source descriptions of 'Abigail', 'Rose de Berne', and 'Strawberry Fields' mentioned minimal cracking or resistance or tolerance to cracking. We observed the expression of this trait to be strongest for 'Strawberry Fields' in our evaluation. Indeed, 'Strawberry Fields' produced significantly less unmarketable fruit per plant than any other cultivar evaluated and a higher marketable yield per plant than 'Mountain Rouge'.

Fruit from 'Strawberry Fields' was red at maturity. For markets demanding pink fruit, 'Rose de Berne' produced more marketable tomatoes than 'Mountain Rouge'. By marketable weight per plant, all four pink-fruited cultivars ('Rose de Berne', 'Damsel', 'Mountain Rouge', and 'Abigail') were not different from each other. It should be noted that all four produced significantly lower marketable yield per plant by weight than the red-fruited cultivars.

The commonality between all the cultivars we evaluated was that they were slicing tomatoes and had resistance to Late Blight. They differed in size (medium and large), shape (standard and heirloom), and fruit color at maturity (red and pink).

Very few tomatoes were extra-large. We didn't observe any cultivar produce a different number of extra-large fruit per plant than 'Mountain Rouge'. 'Abigail' produced a higher weight of extra-large fruit per plant than 'Mountain Rouge'. 'Abigail' was described as producing the largest-sized (10-16 oz) fruit in this evaluation (Table 1). Fruit were an heirloom type. They were

Organic Late Blight Tomato Cultivar Evaluation (continued from page 52)

'Strawberry Fields' produced a higher marketable yield (number per plant) and lower unmarketable yield (pound per plant) compared to other indeterminate late blight-resistant tomato cultivars.

Photo: Tom Butzler

largely flattened in shape and tended to have gnarly blossom ends. Many fruit were discarded because of the extent of the blossom end scars. 'Abigail' may be more suited for home gardens.

Most fruit fell in the large- and medium-sized categories. The red-fruited cultivars produced more large-sized fruit per plant by number and weight than 'Mountain Rouge', while the pink-fruited ones were not different. Any of the red-fruited cultivars may be good options for large-sized fruit. The pink-fruited cultivars produced a smaller amount of large-sized fruit per plant; however, they may be grown for markets demanding pink fruit. Using other visual and flavor characteristics may help determine which cultivars to grow for large-sized fruit. We noted, for example, that 'Beef Maestro' produced a blocky fruit compared to the other cultivars, and 'Strawberry Fields' produced very uniform fruit.

'Strawberry Fields' and 'Rose de Berne' produced more medium-sized fruit per plant by number and weight than 'Mountain Rouge'. These may be good options for red- and pink-fruited cultivars, respectively.

Very few fruit were categorized as small. Additionally, very few statistical differences were observed in this category. None of the cultivars we evaluated were described by seed companies as small-fruited. We did not observe enough small-sized fruit to be able to make a cultivar recommendation for this category.

Determinate Evaluation. 'Mountain Merit' was used as the standard.

Less visual differences were present between the determinate cultivars than the indeterminate ones. All cultivars evaluated were red-fruited, medium-sized slicers. Marketable yields were higher by number per plant from 'Defiant', 'Stellar', and 'Iron Lady', and by weight from 'Defiant' and 'Stellar' than 'Mountain Merit'. As observed in the indeterminate evaluation, excessive water-related issues (cracking and rain check) were the primary cause of culled fruit. Apart from 'Defiant', all cultivars produced more unmarketable than marketable fruit per plant by number, and apart from 'Stellar', all cultivars produced more unmarketable than marketable fruit per plant by weight. 'Defiant' and 'Stellar' produced more unmarkable fruit per plant than 'Mountain Merit'. However, no differences were observed by mean unmarketable weight per

The red-fruited cultivars produced more large-sized fruit per plant by number and weight than 'Mountain Rouge', while the pink-fruited ones were not different. Any of the red-fruited cultivars may be good options for large-sized fruit.

Continued on page 56

Evaluating Integrated Weed Management Approaches in Vegetables

***Dwayne D. Joseph - University of Maryland Extension**
709 Morgnec Rd, Ste 202, Chestertown, MD. dwaynej@umd.edu

Alan Leslie – University of Maryland Agricultural Experiment Station, College Park, MD
Kurt Vollmer – University of Maryland Extension, Queenstown, MD
Cerruti Hooks – University of Maryland, Department of Entomology, College Park, MD

Vegetable farmers face persistent challenges with weed management, both within and between the crop row, requiring targeted strategies for effective management. An Integrated Weed Management (IWM) approach is especially critical in vegetable production, where fewer herbicides are registered compared to row crops. Many available herbicides do not provide full-season weed control and may increase the risk of crop injury if not applied as labeled. As a result, weeds are consistently ranked as a top production constraint by farmers, who devote significant time and labor to chemical, manual, and mechanical weed control. Compounding this issue is the need to tailor weed management tactics based on whether weeds occur within or between rows.

***Dwayne Joseph** is the Agriculture and Food Systems Extension Agent for the University of Maryland Extension in Kent County. His research and programming focus on developing integrated weed management strategies for vegetable and agronomic crops. Through his work, he helps farmers tackle persistent weed control challenges while promoting sustainable production practices. Dwayne earned a B.S. in Biology from Grambling State University and an M.S. and Ph.D. in Plant and Environmental Sciences from Clemson University. Originally from the Caribbean island of St. Lucia, he now calls the Delmarva home.*

To address these challenges, this study evaluated IWM strategies for their effectiveness in managing weeds within organic vegetable systems. Specifically, it focused on using a living mulch (red clover) for between-row weed management, combined with various conservation tillage and soil disinfection practices for within-row weed control. One soil disinfection technique assessed was biosolarization, which combines solar heating with organic amendments to suppress weeds and soil pathogens. Biosolarization is compatible with organic systems and offers advantages in climates where traditional solarization may be ineffective or take too long to achieve results. Fruit processing by-products (pomace), such as those from grapes, apples, or tomatoes are particularly suitable for biosolarization due to their abundance, low cost, and lack biohazard risks compared to animal by-products. In addition to biosolarization, cover crops provide numerous benefits to vegetable production, including improved soil health, erosion control, and enhanced attraction of beneficial insects such as pollinators, natural enemies, and epigeal predators. Cover crops are also highly effective at suppressing weeds, especially when used as a living mulch. By competing with weeds for space, nutrients, and other resources, cover crops create an environment that is less conducive to weed growth.

The main objective of this study was to demonstrate the utility of biosolarization, conservation tillage and cover cropping as

Evaluating Integrated Weed Management Approaches in Vegetables (continued from page 54)

strategies to reduce weed infestations. The study utilized a randomized complete block design with four treatments replicated four times. The study was conducted in 2023 and 2024 at the Central Maryland Research and Education Center in Upper Marlboro, MD. The four treatments comprised of organically managed summer squash and okra: 1) grown with a living mulch + no-till (LM-NT), 2) interplanted with cover crops (LM-ST), 3) grown in solarized soil (Sol), or 4) interplanted with a cover crop and grown in biosolarized soil (Biosol).

In early fall, all plots were seeded with a cover crop mix of red clover and cereal rye. In the LM-NT plots, however, red clover and cereal rye were seeded in alternating rows (six rows of cereal rye, four rows of red clover), with cereal rye corresponding to the within-row area designated for the cash crop.

In the spring, cereal rye in the Biosol plots was mowed to terminate growth. The between-row areas were then strip-rotovated (40 inches wide). Grape pomace was applied to the rotovated zones and incorporated into the soil using a strip rotovator. Transparent plastic tarps and drip irrigation lines were installed over the treated zones, initiating the biosolarization process, which lasted for 12 days. After this period, the tarps were removed, and the soil was aerated for seven days before transplanting summer squash and okra. In the Sol treatment plots, the entire plot was mowed and rotovated. Transparent plastic tarps and drip irrigation lines were then installed over the intra-row areas to facilitate solarization. In the LM-NT plots, cereal rye was terminated using a roller crimper, which also temporarily stunted the growth of red clover. The cash crop was then transplanted directly into the roller-crimped cereal rye mulch. In the LM-ST treatment plots, the entire plot was roller crimped to terminate the cereal rye. The intra-row areas were strip-rotovated (40 inches wide) immediately before transplanting the cash crop. In the LM-NT, Biosol, and LM-ST plots, red clover was left between the rows to function as a living mulch. Data collection included crop yield, weed counts (species and density) at 2, 4, 6, and 9 weeks after planting (WAP). Also, soil nematode counts were recorded, along with observations of beneficial arthropods, natural enemies, and epigeal predators throughout the growing season.

The main objective of this study was to demonstrate the utility of biosolarization, conservation tillage and cover cropping as strategies to reduce weed infestations.

The results showed that overall, Biosol plots had the lowest mean weed counts within the crop row compared to the other treatments. This was followed by LM-NT and LM-ST, while Sol plots recorded the highest mean weed counts within the crop row. Between the crop rows, LM-NT exhibited the lowest mean weed counts, followed by LM-ST and Biosol, with Sol plots having the highest mean weed counts — more than ten times that of the LM-NT plots. In summer squash, Biosol plots yielded the highest, followed by Sol, LM-NT, and LM-ST, which had the lowest yields. Conversely, in okra, Sol plots produced the highest yield, followed by Biosol, LM-NT, and LM-ST, which had the lowest yields.

The results suggest that biosolarization is a viable option for weed management within the crop row. It consistently provided superior weed suppression compared to other within-row treatments while maintaining yields across both crops. In organic production systems, biosolarization offers an alternative to residual

Continued on next page

Organic Late Blight Tomato Cultivar Evaluation (continued from page 53)

plant. Overall, 'Defiant' and 'Stellar' appear to be the best options based on marketable yield.

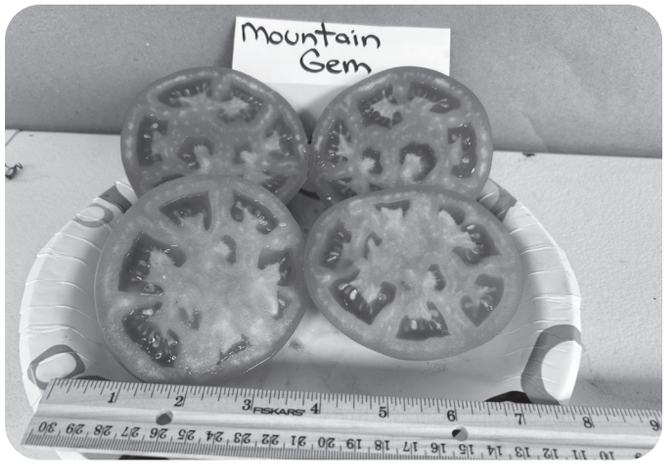
Notably, most 'Defiant' culls had yellow shoulder. While some other cultivars also exhibited this disorder, 'Defiant' seemed to be especially prone. Tomatoes have a high need for potassium during fruiting. 'Defiant' may have a higher need relative to other cultivars.

'Mountain Gem' produced more extra-large tomatoes per plant than 'Mountain Merit'. In fact, 'Mountain Gem' was the only cultivar that produced more than one extra-large tomato per plant. 'Mountain Gem' appears to be the best option among the cultivars evaluated for producing extra-large fruit, although the amount of fruit in this category was small.

All cultivars may be good options for large-sized fruit as none differed from 'Mountain Merit'.

Overall, the largest category of fruit was medium-sized. 'Stellar' and 'Defiant' produced more medium-sized fruit by number and weight than 'Mountain Merit' and may be good options. 'Stellar' is reportedly resistant to Early Blight (caused by *Alternaria solani*) and Septoria Leaf Spot (caused by *Septoria lycopersici*), two other commonly encountered diseases in tomato production.

Too few fruit were small to recommend which cultivar to grow in this category.



'Mountain Gem' stands out for its ability to produce extra-large tomatoes, surpassing other cultivars in both number and weight in the determinate late blight-resistant tomato cultivar trial.

Photo: Tom Butzler

Evaluating Integrated Weed Management Approaches in Vegetables (continued from page 55)

herbicides by delivering early-season weed control, which provides crops with a competitive advantage against weeds during the critical early-growth stages.

While biosolarization plots had the fewest weeds within the crop row, the weeds that did emerge were primarily located along the edges of the row, where maximum soil disturbance occurred during the mechanical application and subsequent removal of the tarp. To mitigate this issue in future applications, alternative methods for laying and removing biosolarization tarps with minimal soil disturbance will be explored, this will potentially reduce weed pressure along the shoulder areas significantly. Between the crop rows, the living mulch proved effective at suppressing weed infestations. However, there is concern regarding the competitiveness of the red clover living mulch with the crop, which may have negatively impacted yields. This was particularly evident in okra, where solarized plots (without living mulch) exhibited the highest yields despite having the greatest weed pressure. Future research could focus on mitigating this competition by exploring lower-growing clover species, and increasing the distance between the crop row and the living mulch to reduce interspecific competition.

Peppers: Preserving Pepper Production by Tackling Anthracnose

Sarah Pethybridge[1] and Elizabeth Buck[2]

Anthracnose fruit rot is a significant and highly destructive disease of all peppers, caused by multiple Colletotrichum spp. that severely affects fruit yield and marketability. The disease is found throughout the eastern United States with varying severity.

There are two types of anthracnose affecting peppers:

(i) **Ripe or Late Fruit or 'Common' Anthracnose (RFA);**

(ii) **Green or Early Fruit Anthracnose (GFA).**

This summary will focus on GFA due to its recent emergence in this region and highly destructive nature of the disease.

Symptoms. Symptoms may be found on all plant parts, but immature (pre-harvest) and ripe fruit (post-harvest) is the most severely affected. When the fungus is seedborne, infection may cause pre- and post-emergence seedling death. Leaf symptoms are relatively rare, but they may be infected and asymptomatic. The infected leaves typically remain asymptomatic due to suppressed fungal growth until crop senescence after which symptoms appear. These infected and diseased leaves then serve as an inoculum source for infection of the developing fruit and other leaves Infected fruit left in the field during the production season act as a source of inoculum. Symptoms on fruit are large, sunken necrotic lesions with concentric rings of black or orange acervuli, with simple fruiting bodies that produce masses of asexual spores (conidia) of *Colletotrichum* spp. (**Fig. 1**). Older lesions tend to be an orange color due to profuse production of spores on the affected tissue. As the spores are produced on the plant surface for dispersal by rain splash and other means to infect plant parts, this is the main reason that anthracnose spread is rapid within the season. Latently infected fruit can also be problematic. These fruits appear healthy when picked but may rapidly develop symptoms following harvest.

Background. GFA is a particularly severe type of anthracnose, caused by C. *scovillei*, and has recently been identified in several major pepper producing regions across the Northeastern United States and in Ontario, Canada.

Continued on next page

[1] Plant Pathology & Plant-Microbe Biology Section | Cornell AgriTech | Geneva, NY 14456

[2] Cornell Vegetable Program | Cornell Cooperative Extension | East Aurora, 14052

Sarah Pethybridge *is an Associate Professor (Plant Pathology) at Cornell AgriTech, Geneva, New York. She earned her B. Agr. Sc. (Hons) and Ph.D. in Plant Pathology from the University of Tasmania, Australia She joined Cornell University in 2014 after plant pathology roles in Australia and New Zealand. Her program focuses on the epidemiology and management of diseases affecting vegetables in conventional and organic production. She and her husband, Frank have two children, Emily and James.*

Elizabeth Buck *is a fresh market vegetable specialist within the Cornell Vegetable Program, serving the western-most NY counties. She completed a B.S. in Plant Sciences and Agricultural Sciences at Cornell University and a l'vl.S. at the University of Guelph, Canada, studying integrated weed management systems in vegetable production. She is an active member of the Northeastern Weed Science Society and the Great Lakes Vegetable Working Group.*

Peppers: Preserving Pepper Production by Tackling Anthracnose (continued from page 57)

Fig. 1. Green fruit anthracnose caused by *Colletotrichum scovillei* on banana peppers in NY

- *South Carolina.* The disease was first identified in SC in 1998, but recently severe outbreaks have occurred. In outbreaks on commercial farms in 2019, disease incidence was estimated at ~20% and 50%, respectively. In the initial outbreaks in SC, bell, cubanelle, and banana peppers were more severely affected than serrano and jalapeno peppers.
- *Ohio.* Outbreaks were first found in 2019. In Columbiana County, OH, GFA was reported in 2019 across multiple locations with a disease incidence and severity of 100% and 70%, respectively.
- *Ontario, Canada.* The disease was first reported in 2010, and substantial crop losses have occurred, including annual fruit loss estimates of up to 80% for the last 3 years. For example, in banana pepper fields in 2021 GFA was first identified in late July and within 2 weeks 80% of fruit were declared unmarketable.
- *New York.* GFA was first identified in NY in 2023 after banana pepper fruit with severe symptoms were found in western counties. The disease was also found at the same location affecting peppers in 2024. Crop loss manifested as unmarketable fruit not fit for sale but also rapid post-harvest decay after sale which may have contributed to the spread of primary inoculum across the region.
- Observations in MI and NJ have also raised concerns surrounding GFA.

The lifecycle of C. *scovillei* highlights the role of multiple sources of pathogen inoculum that can initiate anthracnose outbreaks (**Fig. 2**). Primary inoculum that initiates epidemics is likely to be introduced by either **infested seed or transplants, or infested crop residue or farming equipment** (e.g., stakes for canopy management) from the previous seasons. C. *scovillei* also causes anthracnose in other crops including watermelon (and other Cucurbitaceae). Disease spread is promoted by temperatures ~80^{0}F (27^{0}C) and high rainfall. Rain splash and wind-blown rain is the main way spores are dispersed between infected plant residue, soil, and plants to cause new infections.

Management

Effective anthracnose management therefore relies upon an integration of strategies to reduce the influence of primary inoculum to initiate infections and in-season management tactics to protect foliage from infection. Cultural practices include:

- Use of **certified seeds** and/or **transplants** to avoid introducing the pathogen with planting material.
- **Crop rotation** with non-host crops (i.e., not within the Solanaceae and strawberries) for 2-3 years.

Peppers: Preserving Pepper Production by Tackling Anthracnose (continued from page 58)

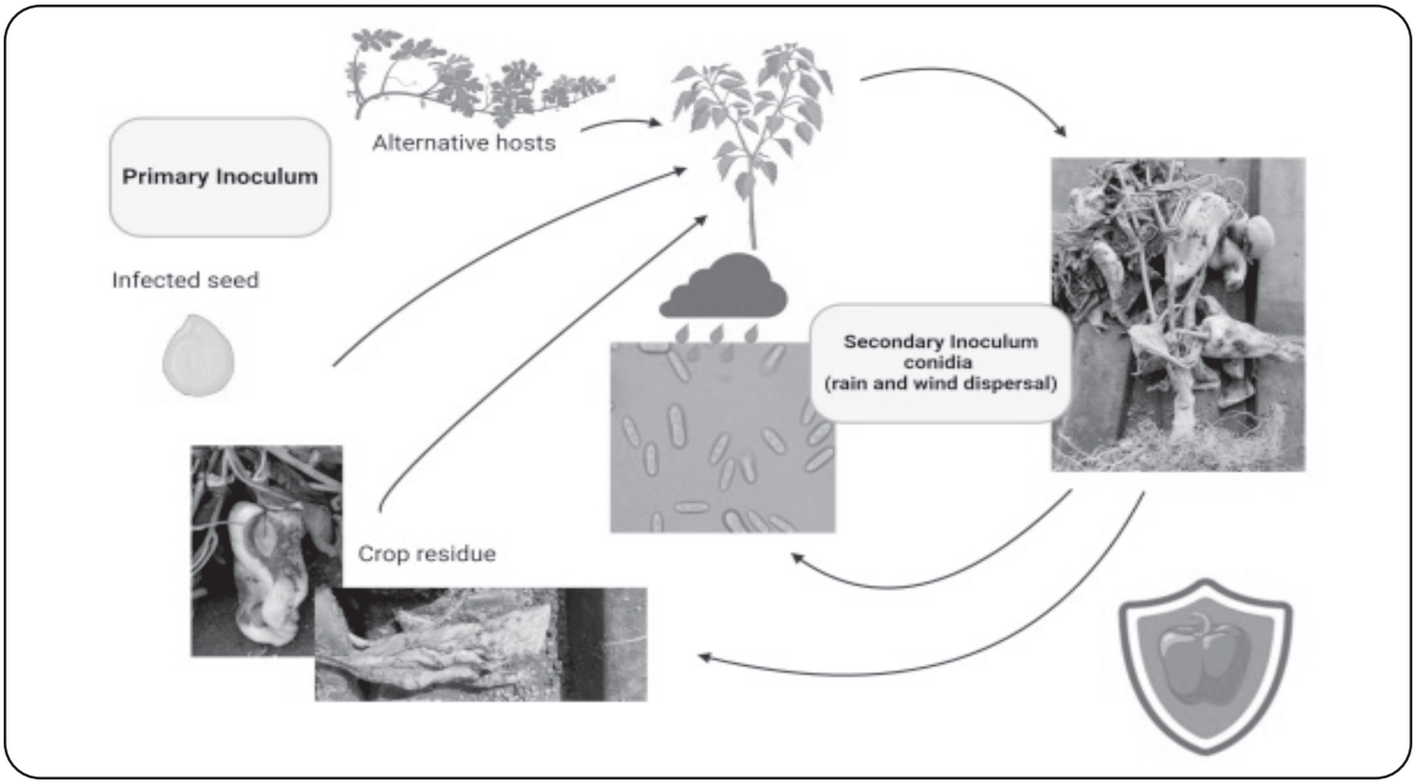


Fig. 2. Lifecycle of Anthracnose of pepper.

- **Burial/incorporation of infested leaf debris** into the soil soon after harvest to enhance decomposition.
- **Minimizing leaf wetness** by avoiding overhead irrigation. Consider drip irrigation where practical.
- **Limited field operations** will also slow spread and spores can be spread on equipment and clothes.
- **Control of weeds and volunteers** will reduce the availability of plants that may form a green bridge for the pathogen to peppers.
- **Soil barriers** such as black plastic mulch or straw or wood chip mulch will minimize the contact between fruits and the soil and infested plant debris.
- **Cultivar selection.** There are currently no resistant pepper cultivars to anthracnose.
- **Fungicides.** For effective control within the season, fungicides should be applied to protect the flowers from infection.
- **SCOUTING** frequently will identify early disease outbreaks and provide the opportunity for control.

Rain splash and wind-blown rain is the main way spores are dispersed between infected plant residue, soil, and plants to cause new infections.

Current Research on Flea Beetle Management and Review of New Insecticides for Fruiting Vegetables

Thomas P. Kuhar
Dept. of Entomology, Virginia Tech | Blacksburg, VA 24061-0319
tkuhar@vt.edu

In the Mid-Atlantic U.S., flea beetles are common pests on eggplant, where they often attack young seedlings and feed in mass on leaves resulting in characteristic "shot-hole" appearances. The predominant flea beetle species attacking eggplant in our region are the eggplant flea beetle (*Epitrix fuscula*) and tobacco flea beetle (*Epitrix hirtipennis*). High densities of these insects can riddle leaves with holes.

Effect of flea beetle feeding injury on eggplant yield. A few years ago, my lab conducted field experiments in Whitethorne, VA to determine the effect of leaf feeding by these tiny pests on eggplant yield. Results showed that flea beetle defoliation levels exceeding 21% (in the first 30 days after transplanting) resulted in significant yield loss to eggplant (Fig. 1). This confirms that

Tom Kuhar *is a Professor in the Department of Entomology at Virginia Tech. He has been a regular speaker at the MAFVC since the mid-2000s. Dr. Kuhar's research focuses on the integrated pest management of pests of potato and vegetable crops. He has trained over 40 graduate students and has published ~ 160 peer-reviewed papers and 6 book chapters on insect pest management in agricultural crops. A native of Baltimore, MD, 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.*

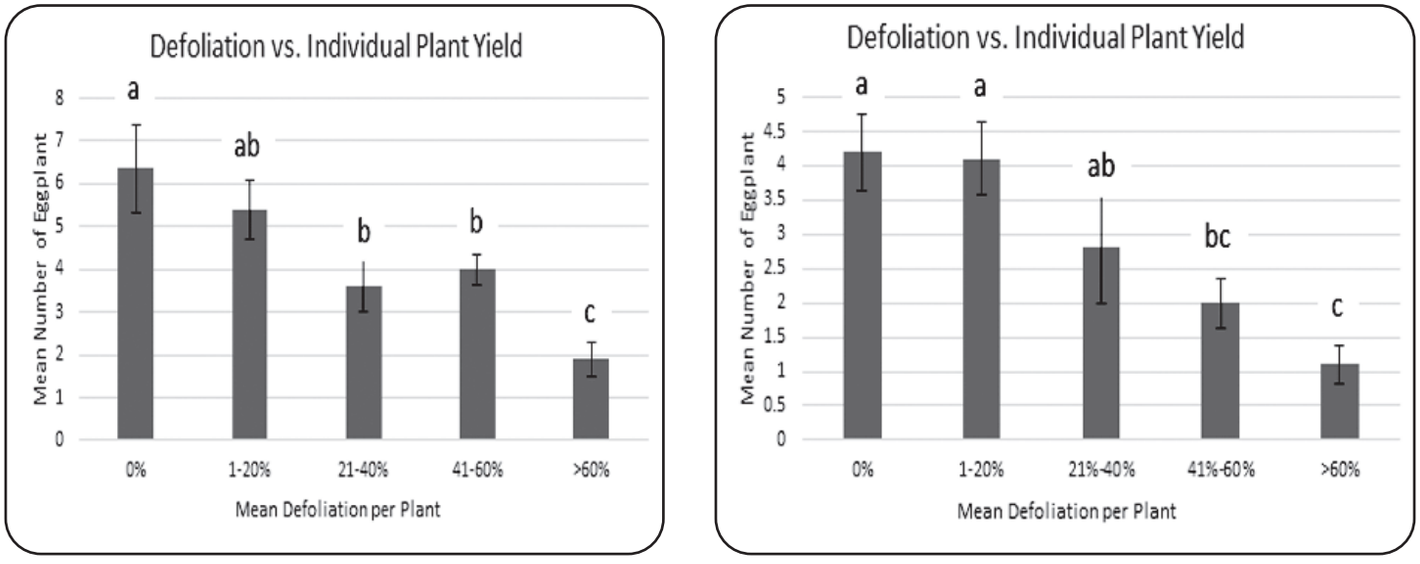


Fig. 1. Yield of 'Classic' eggplant in 2015 (A) and 2016 (B) under increasing levels of flea beetle defoliation for the first 30 days of plant growth. One month after transplanting, all plants were treated with insecticides to eliminate any additional insect damage.

Current Research on Flea Beetle Management and Review of New Insecticides for Fruiting Vegetables (continued from page 60)

Table 1. Flea beetle counts and yield of 'Classic' eggplant treated with different soil-applied or foliar-applied insecticides in Whitethorne, VA. Eggplant was transplanted 22 May 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 fl oz/A	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 – soil drench	7.3	9.0c	3.5b	29.0cd	12.3b	60.0a
Venom 70SG – soil drench	6.0	1.5c	1.8b	6.0d	29.8a	60.0a
Verimark 1.67SC – soil drench	6.75	31.3b	44.0b	65.3b	8.6b	56.0a
Admire Pro 4.6SC - foliar	1.3	12.3c	23.5b	134.0a	9.7b	48.0ab
Venom 70SG - foliar	1.0	5.5c	8.3b	62.3bc	7.0b	55.8a
Exirel 0.83E - foliar	13.5	8.5c	29.5b	95.0b	9.2b	55.0a
Brigade - foliar	2.1	1.5c	5.3b	10.5d	12.0b	61.8a

Table 2. Counts of flea beetles and eggplant yield after applications of organic and other novel insecticides spring 2024, Whitethorne, VA.

Treatment Product*	Rate fl oz/A	No. flea beetles per 5 plants June 10, 2024 (3 DAT 1)	No. flea beetles per 5 plants June 21, 2024 (3 DAT 2)	Yield - #'s of eggplant fruit per 15 ft plot on Aug 10
UTR	-	9.50	21.50 a	8.75
Seican[1]	48	1.75	17.00 ab	5.75
TetraCURB MAX[2]	64	2.00	15.50 ab	6.00
PFR-10% ES[3]	32	1.00	5.75 cd	8.00
BoteGHA Optima[4]	32	5.50	17.50 ab	5.00
Entrust SC[5] (standard)	4	6.50	9.00 bcd	2.50
Azera[6] (pyrethrins + azadirachtins)	19.4	3.75	9.75 bcd	9.50
Plinazolin 200SC[7] **(not organic)**	4	0.00	1.00 d	7.50
P-value from ANOVA		0.1538 NS	0.0019	0.2619 NS

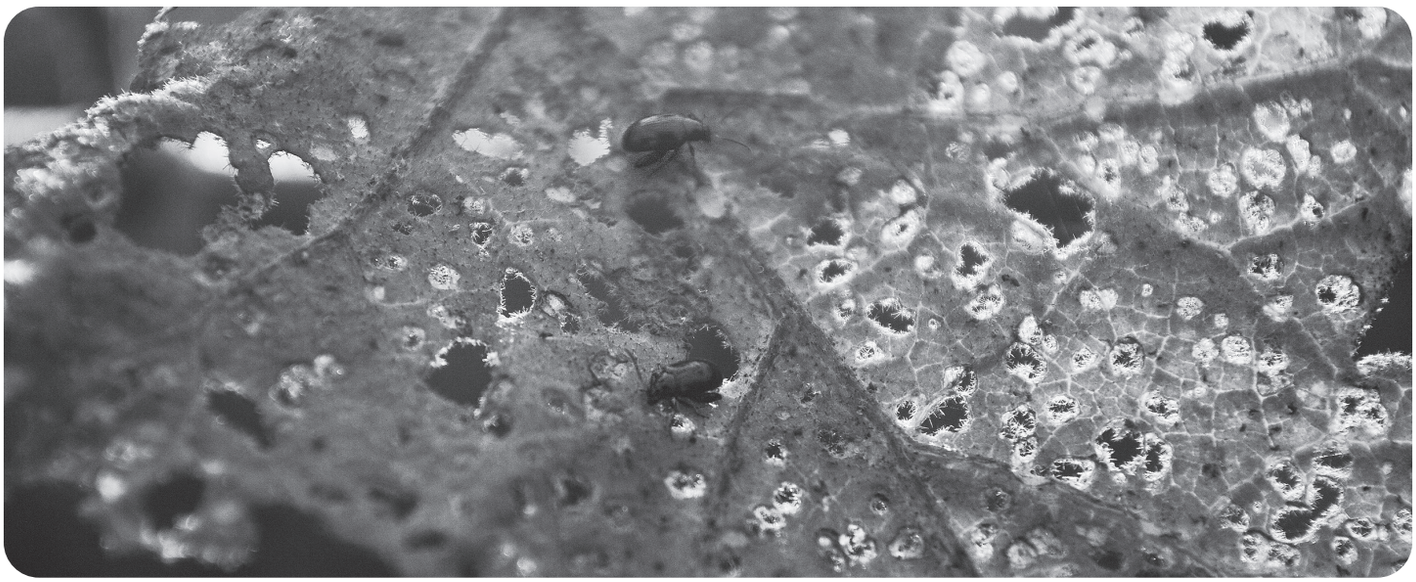
[1]**Seican** (Cynnamaldehyde) Summit Agro: Registered for use but flea beetles not on label. [2]**TetraCURB MAX** (Castor oil, rosemary oil, clove oil, peppermint oil). Kemin: FIFRA Exempt product. [3]**PFR-10% ES** (*Isaria fumosorosea* Apopka Strain 97) Certis USA Registered for use; flea beetles not on label. [4]**BoteGHA Optima** (*Beauveria bassiana* strain GHA) Certis USA, Not registered. [5]**Entrust SC:** Registered in the USA. [6]**Azera** (Azadirachtin + Pyrethrins), Valent Biosciences, Registered in the USA. [7]**Plinazolin 200SC** (isocycloseram) Syngenta Crop Protection. Not currently registered.

flea beetles need to be effectively controlled in eggplant in order to maximize yields.

Efficacy of soil drench or foliar insecticides for flea beetle control. Because flea beetles attack very young seedlings, sometimes even before the transplants go into the ground, drenches of systemic insecticides such as neonicotinoids or diamides are suggested options for controlling

Continued on next page

Current Research on Flea Beetle Management and Review of New Insecticides for Fruiting Vegetables (continued from page 61)



these pests. In Virginia we evaluated the efficacy of three soil drench commercial insecticides Admire Pro (imidacloprid), Venom (dinotefuran), and Verimark (cyantraniliprole) as well as four foliar spray treatments: Admire Pro, Venom, Exirel (same active ingredient as Verimark), and the pyrethroid Brigade (bifenthrin). Randomized complete block small plot experiments were conducted on 'Classic' eggplant in Whitethorne, VA. All insecticides tested provided effective kill of flea beetles at 1 wk post application on both crops (Table 1). At 21 days after drench application, Venom provided better control than the other two soil insecticides, which essentially no longer provided any effective kill (Table 1 – June 13 data). Brigade (bifenthrin) performed the best among the four foliar treatments. This work is published in: *Mason, J., A. Alford, and T. P. Kuhar. 2020. Flea beetle (Coleoptera: Chrysomelidae) populations, effects of feeding injury, and efficacy of insecticide treatments on eggplant and cabbage in Southwest Virginia. J. Econ. Entomol.113(2):887-895. doi: 10.1093/jee/toz355.*

Efficacy of organic and bio-based insecticides for flea beetle control. Organic growers have particular challenges managing flea beetles. With support from the IR-4 Project # IS00427, we evaluated the efficacy of several bio-based and organic insecticide options for control of flea beetle on eggplant in Virginia in 2024. The experiment was conducted in Whitethorne, VA on 'Nadia' eggplant that were spaced 1 ft apart on white plastic mulch beds. There were 8 treatments (see Table 2) arranged in a randomized complete block design. On June 7 and June 18, all treatments were applied with a 3-nozzle boom equipped with D3 spray tips powered by a CO_2 backpack sprayer at 40psi delivering 36 GPA. Flea beetles were comprised 60% Eggplant flea beetle (Epitrix spp.) and 40% tobacco flea beetle (Epitrix hirtipennis).

Results. On June 10, there was no significant effect of treatment on numbers of flea beetles although the untreated control appeared to have the most beetles (9.5 beetles per 5 plants) and the Plinazolin treatment had zero beetles. On June 21, there was a significant effect of treatment on beetle numbers with the untreated control having the most beetles (21.5 beetles per 5 plants). Four of the treatments significantly reduced beetle numbers including Plinazolin, PFR-10%, Entrust and Azera. There was no significant effect of treatment on number of eggplant fruit per plot.

Organic Potatoes – Five Years In

Nolan Masser | Red Hill Farm

Five years ago we experimented with growing 2 acres of organic potatoes. We thought at the time it would be a small portion of our business, but it has since grown more than 40 acres.

So what have we learned?

Marketing is the biggest key to success.

We started with 2 small customers and a few leads. Since then, we have concentrated on a few key relationships that allow us to know where 75 percent of our crop is going before it is planted.

Organic potatoes are in the process of being commoditized and we try to not compete with organic potatoes grown outside of the North Eastern US. Instead, we try to identify customers who value locally or regionally grown potatoes in addition to the organic stamp. This issue is part of the identity crisis certified organic as a whole is suffering. Organic was built on the assumption that the farmers would be "small" family operations in "close" proximity to their consumers. This does not fit the corporate food model and the landscape is continually changing.

How the land is managed before the potato crop is critical.

We grow a winter grain the year after a potato crop and follow that with 2.5 years of a grass pasture mix. Rotationally grazing cattle on the land adds carbon and stimulates as much microbial activity as possible. At times bale grazing the fields in the off years adds an even bigger infusion of organic matter. If not, pen pack manure is added, then plowed down the fall before the potato crop. The goal is to have a carbon and nutrient rich, yet stable soil for the potatoes.

Variety choice is very important.

Most modern varieties thrive in a high synthetic nitrogen, chemically dependent system. Organic requires a variety that thrives well on its own without much intervention. It needs to grow quickly and aggressively to out compete weeds and pests. We are happy with the Fenway variety of reds, but are still searching for the perfect gold….

Nolan Masser's *family has been farming in central Pennsylvania since the Revolutionary War. Ten years ago, they recognized the problems the current agriculture system was causing their farmland and the food they produced. Since then, their goal has been to produce clean, healthy food while improving the environment. They raise organic and non organic crops while grass finishing beef and pasture raising eggs and poultry. They market their food through wholesale channels and direct to consumer at redhillharvest.com.*

Weed control starts before there are any weeds visible.

Much time is spent on hands and knees scratching the surface for germinating weeds. Since we plant on a bed system, an Einboch Fusion weeder is used 2-3 times on the uneven beds. We follow up with a Hillside Cultivator to roll the soil back to the plants. An early start is essential to good weed control and is more about getting the potatoes ahead of weeds rather than killing them all.

Insects and disease have not been as large of an issue previously thought.

Colorado potato beetle pressure has been light and can be controlled with organic pesticides. Aphids can be an issue, but pollinator species are planted with the potatoes and along the

Continued on page 66

New Potato Varieties Coming Out of the NY/Cornell Pipeline

Walter De Jong
School of Integrative Plant Science
Cornell University | Ithaca, NY 14853
wsd2@cornell.edu

The Cornell potato breeding program seeks to serve the potato industry of NY and PA and neighboring states by developing new varieties that are adapted to the local environment and meet the evolving needs of growers, processors and consumers alike. The emphasis is to combine resistance to the golden nematode and scab with other attributes (e.g., yield, appearance, freedom from internal defects) needed in a successful variety. Primary market niches targeted by the program include round white varieties with resistance to low temperature sweetening and high dry matter for the chipping industry and round white and red-skinned cultivars for fresh market use.

Descriptions of six of our most promising advanced clones follow below. Comments on the performance of these clones or any previously released Cornell varieties, or on desired attributes of future varieties are always welcome.

NY173 (Q38-4) = J110-12 x F31-3 (2013) Full season chipstock.

- In seven Tompkins County trials over the past seven years, marketable yields averaged 118% of Atlantic.
- Yield in Steuben and Wyoming counties averaged 102% of Atlantic in 2020, 134% in 2021, 95% in 2023, and 115% of Atlantic in 2024.

Tubers are round/compressed with lightly textured skin. Low levels of pickouts (secondary growth and growth cracks) and internal defects (hollow heart) have been observed. Specific gravity has averaged 0.006 less than Atlantic (15 trials). Chip color from 44F storage in December, January and February (2018 crop season) averaged 5.3 compared to 4.8 for Snowden

***Walter De Jong** has been the potato breeder at Cornell since 2000. Varieties he has released include Lehigh, Lamoka, Lady Liberty and Waneta.*

(lower is better), 3.0 vs 4.7 in 2019, 3.7 vs 4.3 in 2020, and 3.8 vs 5.0 in 2021. Moderately resistant to common scab. Molecular markers suggest NY173 is resistant to potato virus Y. Total glycolalkaloids have been modest (7.2 mg/100 g FW in 2018, 4.9 in 2019, 7.5 in 2020). Tuber dormancy is about one week longer than Atlantic. Resistant to race Ro1 of the golden nematode.

NY174 (Q106-13) = NY148 x E48-2 (2013) High yielding, full season chipstock.

- In seven Tompkins County trials over the past seven years, marketable yields averaged 117% of Atlantic.
- Yield in Steuben and Wyoming counties averaged 135% of Atlantic in 2020, 129% in 2023, and 156% of Atlantic in 2024. Yield in Wyoming county in 2021 was 141% of Atlantic.
- Yield in PA averaged 120% of Atlantic in 2023 (3 trials).
- Marketable yield at 12 locations in nationwide 2023 SNAC trials averaged 106% of Snowden, while specific gravity averaged the same as Snowden.

Tubers are round to oblong with lightly textured skin and a moderately recessed apical eye. Low levels of pickouts (secondary growth and growth cracks) and internal defects (hollow heart, internal necrosis and brown center) have been observed in most trials, although a high level

New Potato Varieties Coming Out of the NY/Cornell Pipeline (continued from page 64)

of heat necrosis was observed in the Missouri 2023 SNAC trial. Specific gravity has averaged 0.001 less than Atlantic (17 trials). Chip color from 43F storage in January and February (2018 crop season) averaged 4.0 compared to 4.2 for Snowden (lower is better). Chip color from 44F storage in December, January, and February averaged 3.0 vs 4.7 in 2019, 3.7 vs 4.3 in 2020, 2.7 vs 5.0 in 2021, 2.7 versus 5.0 in 2022, and 3.3 vs 5.3 in 2023. Intermediate reaction to common scab. Resistant to late blight race US-23 in PA in 2023. Molecular markers suggest NY174 is resistant to potato virus Y. Total glycolalkaloids have been modest (4.3 mg/100 g FW in 2018, 2.1 in 2019, 5.0 in 2020). Tuber dormancy is about three weeks longer than Atlantic. Resistant to race Ro1 of the golden nematode.

NY175 (Q29-2) = Lady Liberty x F31-3 (2013) Mid-late season chipstock.

- In seven Tompkins County trials over the past seven years, marketable yields averaged 125% of Atlantic.
- Yield in Steuben and Wyoming counties averaged 83% of Atlantic in 2019, 132% in 2021, 114% in 2022, 102% in 2023, and 126% of Atlantic in 2024.

Tubers are round to oblong with moderately textured skin. Low levels of pickouts (growth cracks) and internal defects (hollow heart, internal necrosis and brown center) have been observed. Specific gravity has averaged 0.001 less than Atlantic (17 trials). Chip color from 44F storage in December, January, and February (2019 crop season) averaged 3.7 compared to 4.0 for Snowden (lower is better), 4.3 vs 4.3 in 2020, 4.0 vs 5.0 in 2022, 3.0 versus 5.0 in 2022, and 4.7 vs 5.3 in 2023. Moderately resistant to common scab. Molecular markers suggest NY175 is resistant to potato virus Y. Total glycolalkaloids have been modest (8.1 mg/100 g FW in 2018, 4.1 in 2019, 7.6 in 2022). Tuber dormancy is about one week longer than Atlantic. Susceptible to race Ro1 of the golden nematode.

NY177 (R107-6) = NY148 x E48-2 (2014) Mid-late season chipstock with very high specific gravity.

- In four Tompkins County trials over the past six years, marketable yields averaged 116% of Atlantic.
- Yield in Wyoming county in 2021 was 124% of Atlantic. Yield in Steuben and Wyoming counties averaged 125% of Atlantic in 2022, 89% in 2023, and 96% in 2024.
- Yield in Pennsylvania in averaged 107% of Atlantic in 2022 (2 trials) and 119% in 2023 (3 trials).
- Marketable yield at 12 locations in nationwide 2023 SNAC trials averaged 96% of Snowden, while specific gravity averaged 0.009 higher than Snowden. Yield was dragged down by underperformance in southern states; in the eight northern trial sites, yield averaged the same as Snowden.

Tubers are round to oblong with lightly textured skin. Low levels of pickouts (growth cracks) and internal defects (internal necrosis and brown center) have been observed. Specific gravity has averaged 0.006 more than Atlantic (15 trials). Chip color from 44F storage in December, January, and February (2019 crop season) averaged 2.3 compared to 4.7 for Snowden (lower is better), 2.7 vs 4.3 in 2020, 2.8 vs 5.0 in 2021, and 3.0 vs 5.0 in 2022. Moderate resistance to common scab. Resistant to late blight race US-23 in a PA trial in 2023. Molecular markers suggest NY177 is resistant to potato virus Y. Total glycolalkaloids have been modest (6.8 mg/100 g FW in 2020, 7.9 in 2021, 8.6 in 2022). Tuber dormancy is about one week longer than Atlantic. Resistant to race Ro1 of the golden nematode.

NY179 (R1-7) = Andover x Lady Liberty (2014) Chipstock.

- In four Tompkins County trials over the past six years, marketable yields averaged 110% of Atlantic.

Continued on next page

Organic Potatoes – Five Years In (continued from page 63)

field edges to encourage lady bugs and other predators. We try not to use broad spectrum organic pesticides to protect the pollinators. Blight has not been an issue, but copper can be used as a protectant.

Proper harvest and handling are critical.

Potato vines must be dead and skins set before harvest, but harvest must be completed before weeds overtake everything. A potato topper is used to destroy vines and weeds followed by a flame weeder if necessary.

Refrigeration is a must since no sprout inhibitors can be used.

Where are we going from here?

Conversion to certified organic is a three year process and we are incrementally converting more acres. We are struggling to build fences and grow the beef business at the pace necessary to keep up with the land available for grazing-but the animals are key to the potato production.

The health of the land is key to successful production and is improving but nowhere near where we think it can be. Organic matter and microbial activity need to be increased.

Customers are looking for different types of packages than we are able to pack and upgrades need to be made to our packaging system.

Five years is enough time to identify the potential opportunities and challenges organic potato production faces. We look forward to what can be done in the next five years.

New Potato Varieties Coming Out of the NY/Cornell Pipeline (continued from page 65)

- Yield in Steuben County in 2021 was 90% of Atlantic. Yield in Steuben and Wyoming Counties averaged 127% of Atlantic in 2022, 104% in 2023 and 127% in 2024.

Tubers are round to oblong with moderately textured skin; overall appearance is good. Low to modest levels of hollow heart have been observed. Specific gravity has averaged 0.006 less than Atlantic (11 trials). Chip color from 44F storage in December, January, and February (2019 crop season) averaged 3.7 compared to 4.7 for Snowden (lower is better), 4.0 vs 4.3 in 2020, 4.2 vs 5.0 in 2021, 3.7 vs 5.0 in 2022, and 4.0 vs 5.3 in 2023. Moderately susceptible to common scab. Total glycolalkaloids have been low (4.7 mg/100 g FW in 2020, 5.0 in 2021, 8.9 in 2022). Tuber dormancy is one to two weeks longer than Atlantic. Molecular markers suggest NY179 is resistant to potato virus Y. Resistant to race Ro1 of the golden nematode.

NY182 (R213-2) = Daisy Gold x F11-1 (2014)
Attractive tubers with pink eyes and yellow flesh

- In seven Tompkins County trials over the past six years, marketable yields averaged 104% of Atlantic.
- Marketable yield in Wayne County was 112% of Eva in 2019, 119% of Eva in 2020, 75% of Eva in 2021, 83% of Eva in 2022, 102% of Atlantic in 2023, and 152% of Atlantic in 2024.

Attractive small to mid-sized oblong tubers with smooth to lightly textured skin, pink eyes and yellow flesh. Low levels of pickouts (knobs, secondary growth) and internal defects (hollow heart) have been observed. Specific gravity has averaged 0.016 less than Atlantic (8 trials). Moderately susceptible to common scab. Total glycolalkaloids have been moderate (6.4 mg/100 g FW in 2021, 9.9 in 2022, 2.6 in 2023). Tuber dormancy is similar to Atlantic. Resistant to race Ro1 of the golden nematode.

Understanding Your Insecticide Options for Pest of Potatoes

Thomas P. Kuhar
Professor | Dept. of Entomology,
Virginia Tech | Blacksburg, VA 24061-0319
tkuhar@vt.edu

Kemper Sutton
Assistant Professor | Dept. of Entomology
Virginia Tech Eastern Shore AREC | Painter, VA 23420
klsutton@vt.edu

This presentation will discuss current insecticide options to control key pests of potatoes in the Mid-Atlantic U.S. as well as recent insecticide efficacy trials conducted in Virginia. The two most challenging insect pests to control in potatoes are wireworms (below ground) and Colorado potato beetles (above ground).

Insecticide Options for Wireworms

Wireworms are the larval form of click beetles (Coleoptera: Elateridae) of which many species are persistent agricultural pests worldwide. They are particularly a problem for potato growers because they bore into tubers, which can lead to downgrades in the marketability of the crop, or load rejections. The loss of registrations of many soil insecticides (cyclodienes, organophosphates, and carbamates) has left few insecticide options remaining for wireworm control. Table 1 includes the current registered products for wireworm control.

Broflanilide and plinazolin are two novel insecticides with a new mode of action (meta-diamides – IRAC Group 30). In Canada and Europe, broflanilide and plinazolin have demonstrated great potential for wireworm control. Research has shown that wheat seed treated with Teraxxa (broflanilide) or plinazolin provides outstanding control against *Agriotes* spp. wireworms. Not only do these insecticides protect the wheat crop, but also suppress wireworm populations in the field for subsequent crops. Broflanilide is registered in the grain seed treatment Teraxxa as well as a soil-applied liquid formulation (Nurizma), which can be used as an at-planting in-furrow treatment in potatoes. Plinazolin is not yet registered for use, but will be soon.

Because most of the efficacy work to date with these chemicals on wireworms has focused on *Agriotes* spp. and other European wireworm species, which are not found in the mid-Atlantic

Continued on next page

Tom Kuhar *is a Professor in the Department of Entomology at Virginia Tech. He has been a regular speaker at the MAFVC since the mid-2000s. Dr. Kuhar's research focuses on the integrated pest management of pests of potato and vegetable crops. He has trained over 40 graduate students and has published ~ 160 peer-reviewed papers and 6 book chapters on insect pest management in agricultural crops. A native of Baltimore, MD, 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.*

Kemper Sutton *is a new Assistant Professor of Entomology at Virginia Tech Eastern Shore AREC. His research and Extension will focus on the integrated pest management of pests of potato and vegetable crops. A native of eastern North Carolina, he received his Ph.D. degree in 2022 in entomology from Virginia Tech. He recently finished a postdoctoral position at University of Georgia – Tifton, where he worked on peanut pest management.*

Understanding Your Insecticide Options for Pest of Potatoes (continued from page 67)

Table 1. At-planting (or pre-planting) insecticide options for control of wireworms (and white grubs) in potatoes.

Group	Product Name	Active Ingredient(s) (*=Restricted Use)	Control efficacy on wireworms
1B	Mocap EC	ethoprop*	VG
1B	Thimet 20G	phorate*	VG
2B	Regent 4SC	fipronil	G
3A	Bifenthrin 2EC	bifenthrin*	G
3A	Capture LFR	bifenthrin*	G
3A	Ethos XB	bifenthrin* + *Bacillus amyloliquefaciens*	G
3A+4A	Brigadier	bifenthrin*+imidacloprid	G
3A+4A	Swagger	bifenthrin*+imidacloprid	G
30	Nurizma	broflanilide	VG
Bio-pest	Majestene	Heat-killed Burkholderia spp. strain A396 cells and spent fermentation media	G

U.S., we need to evaluate their efficacy on *Melanotus* spp., which are the primary pest species attacking potatoes in our area. From 2022 to 2024, we conducted both greenhouse container bioassays with field-collected wireworms and field trials in Virginia. These experiments are summarized below.

Soil drench bioassay with Nurizma and plinazolin.

We evaluated liquid formulations of the two Group 30 insecticides, Nurizma (broflanilide) and Plinazolin 300SC. Quart-sized containers were filled ¾ with top soil and each contained a small buried potato tuber plus 5 wireworms. The soil was drenched with the aforementioned insecticides. At 7 days after treatment, ~40% of wireworms were dead in the plinazolin and Nurizma treatments, but notably, 0% feeding injury to potato tubers occurred in these two treatments compared with 100% of tubers damaged in the water control. These data show the potential for these insecticides for wireworm control and protection against tuber damage.

Field trials conducted in potatoes for wireworm control

Small plot field experiments were conducted in potatoes in Painter, VA (Eastern Shore) in 2023 and Abingdon, VA (southwest) in 2023 and 2024. We evaluated both Nurizma (broflanilide) and Plinazolin 300SC as at-planting in-furrow applications. Treatments were arranged in a RCBD with 4-6 replicates. At harvest, tubers were rated for damage from a subsample of 50 per plot. Although we did not always achieve statistical significance across the three field trials, overall results showed that both Nurizma and plinazolin reduced the percentage of wireworm damage similar to if not better than the commercial standard Regent SC (Table 2). These data confirm similar promising trials in Canada and the Pacific Northwest showing that these new Group 30 insecticides provide an efficacious new mode of action for wireworms.

Insecticides for Colorado potato beetle control

Colorado potato beetle is another major pest of potatoes across the U.S. including the mid-

Understanding Your Insecticide Options for Pest of Potatoes (continued from page 68)

Table 2. Effects of in-furrow insecticide treatments on % damaged tubers (with holes) in small-plot field experiments in potatoes in Virginia, 2023 & 2024.

Treatment (in furrow)	Rate / acre	2023 Painter, VA % wireworm damaged tubers	2023 Abingdon, VA % wireworm damaged tubers	2024 Abingdon, VA % wireworm damaged tubers	Avg. % ww damage from all 3 trials
Untreated check		14.0	21.0 a	24.0	19.7
Nurizma	2.3 fl. oz	7.0	6.5 b	15.5	9.7
Plinazolin 300SC	3.43 fl. oz	11.0	7.0 b	15.5	11.2
Regent SC	3.2 fl oz	NA	9.5 b	16.5	13.0
P-value from Anova	ns	0.015	0.006		

Table 3. Potato foliar insecticide evaluation trial conducted in Painter, VA 2024. Potatoes (var. Envol) were planted 9 March 2024.

	Mean no. Colorado potato beetles / 10 stems				% defoliation June 6
	25 May (2 DAT)		3 June (8 DAT)		
Treatment	Small larvae	Large larvae	Small larvae	Large larvae	
Untreated control	20.25 a	33.25 a	5.3 a	27.8 a	40.00 a
Calantha (10% egg hatch) 2 apps	12.00 ab	2.75 b	0.75 b	0.8 b	5.00 b
Rimon 0.83EC (first spray)					
Calantha (2nd spray)	3.75 b	1.00 b	0.00 b	0.00 b	1.8 b
Arvida SG (acetamiprid)	0.00 c	0.0 b	0.0 b	0.0 b	1.0 b
Beseige	0.75 c	0.0 b	0.0 b	0.0 b	1.3 b
Warrior II	0.00 c	0.0 b	0.0 b	0.0 b	1.0 b
Plinazolin (L)	0.00 c	0.0 b	0.0 b	0.0 b	0.8 b
Torac + NIS	0.00 c	0.0 b	0.0 b	0.0 b	0.5 b
	<0.003	0.0001	0.0001	0.0001	0.0001

Atlantic Region. In Virginia, over 50% yield loss can occur if this pest is not managed effectively. Since the mid-1990s, systemic neonicotinoid insecticides such as Admire Pro, Platinum 75SG, Belay, or seed treatments such as Cruiser Maxx have provided excellent control of this pest.

However, the inherent ability of this pest species to develop resistance to insecticides has led to reduced residual efficacy of these insecticides on CPB. Adult beetles that develop on volunteer

Continued on next page

Understanding Your Insecticide Options for Pest of Potatoes (continued from page 69)

potatoes in adjacent fields often move into potato fields after the residual efficacy of neonicotinoids is gone. Furthermore, some potato growers cannot use neonicotinoids on their crops for various regulatory and/or marketing reasons. This has created a greater need for foliar-applied insecticides to control CPB, and, as history has taught us, rotating modes of action is a wise strategy to prevent resistance development in CPB. Diamides insecticides (Coragen, Exirel, Verimark, Harvanta) and spinosyns (Blackhawk, Entrust, Radiant) are excellent IPM-compatible insecticide groups for lepidopteran pests. Our trials have also shown them to provide excellent control of CPB.

Three new insecticides representing different modes of action may provide even more options for potato beetle control. These include: 1) **Torac** (tolfenpyrad) a METI insecticide, which has been registered for a few years, but has not been widely used by potato growers; 2) **Plinazolin**, the same Group 30 insecticide mentioned above for wireworms, but now as a foliar application; 3) **Calantha** is a novel RNAi insecticide recently registered for use on potatoes from Greenlight Biosciences. We evaluated these insecticides in 2024 in a small plot randomized complete block experiment conducted at the Eastern Shore AREC in Painter VA on Envol potatoes. Insecticides were applied Twice: May 15 (at 10% CPB egg hatch) and again May 23.

In addition to Torac, Plinazolin, and Calantha, the treatments also included a Calantha rotation with the IGR insecticide Rimon, along with standards Arvida 30 SG (same as Assail), Beseige which includes a diamide + the pyrethroid lambda-cyhalothrin, and Warror II (Table 3).

Results

- Colorado potato beetle pressure was moderate this year with a mean of 20.3 small larvae and 33.3 large larvae per 10 stems in the untreated check on 25 May (Table 1).
- There were significant treatment effects on counts of small and large CPB larvae on both sample dates. With the exception of small larvae on 25 May, where treatment 2 (Calantha) was not statistically less than the untreated control, all treatments reduced the numbers of CPB larvae statistically on both dates. It should be noted that the numbers of CPB large larvae in the Calantha treatment (2) were not different than the other insecticide treatments (Table 1).
- On 3 June, percentage defoliation averaged about 40% in the untreated control and was barely even detectable in all the other treatments.

Current Research in Cucumber Beetle Management and Pumpkin Grower Survey Results

Thomas P. Kuhar and Demian Nunez
Dept. of Entomology | Virginia Tech | Blacksburg, VA 24061-0319
tkuhar@vt.edu

Pumpkins are an important crop in the Appalachian states namely PA, VA, NC, NY, OH, and TN, with >25,000 planted acres annually. Insects, diseases, and weeds can greatly undermine the economic viability of pumpkin production by increasing production costs and reducing yields. To better understand the challenges facing pumpkin producers a multistate team of university researchers including Drs. Annette Wszelaki (University of Tennessee), Thomas Kuhar, Steve Rideout, Ashley Edwards, Joanne Jones, Katlyn Catron (Virginia Tech), Lynn Sosnoskie, Steve Reiners, Elizabeth Buck, Chris Smart (Cornell University), Inga Meadows, Jim Walgenbach (North Carolina State University), Elsa Sánchez, Tim Elkner, Heather Grabb (Penn State University), Anna Wallingford (University of New Hampshire), Ashley Leach, Jim Jasinski, Logan Minter (Ohio State University), and Kris Holmstrom (Rutgers University) conducted a survey using the Qualtrics survey platform (as well as hardcopies disseminated at grower meetings) in 2023 and 2024. Respondents included193 pumpkin growers from the eastern U.S.

Tom Kuhar *is a Professor in the Department of Entomology at Virginia Tech. He has been a regular speaker at the MAFVC since the mid-2000s. Dr. Kuhar's research focuses on the integrated pest management of pests of potato and vegetable crops. He has trained over 40 graduate students and has published ~ 150 peer-reviewed papers and 6 book chapters on insect pest management in agricultural crops. A native of Baltimore, MD, 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.*

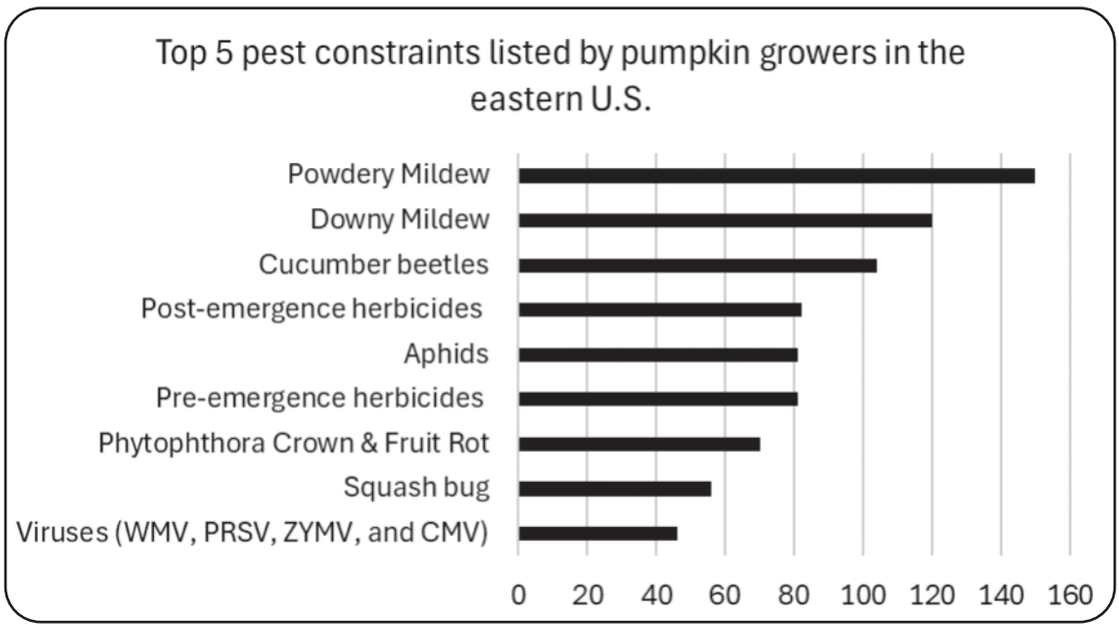
Demian Nunez *is a PhD student working with Dr. Kuhar in the Department of Entomology at Virginia Tech where his research focuses on the integrated pest management of cucumber beetles. He received his dual B.S. degree in biology and environmental studies from Shepherd University in Shepherdstown, WV in 2017 and his Master's degree in entomology from University of Maryland in 2022.*

Pumpkins are an important crop in the Appalachian states namely PA, VA, NC, NY, OH, and TN, with >25,000 planted acres annually. Insects, diseases, and weeds can greatly undermine the economic viability of pumpkin production by increasing production costs and reducing yields.

Continued on next page

Current Research in Cucumber Beetle Management and Pumpkin Grower Survey Results (continued from page 71)

When asked to list their top 5 pest constraints to production, pumpkin growers reported the following:



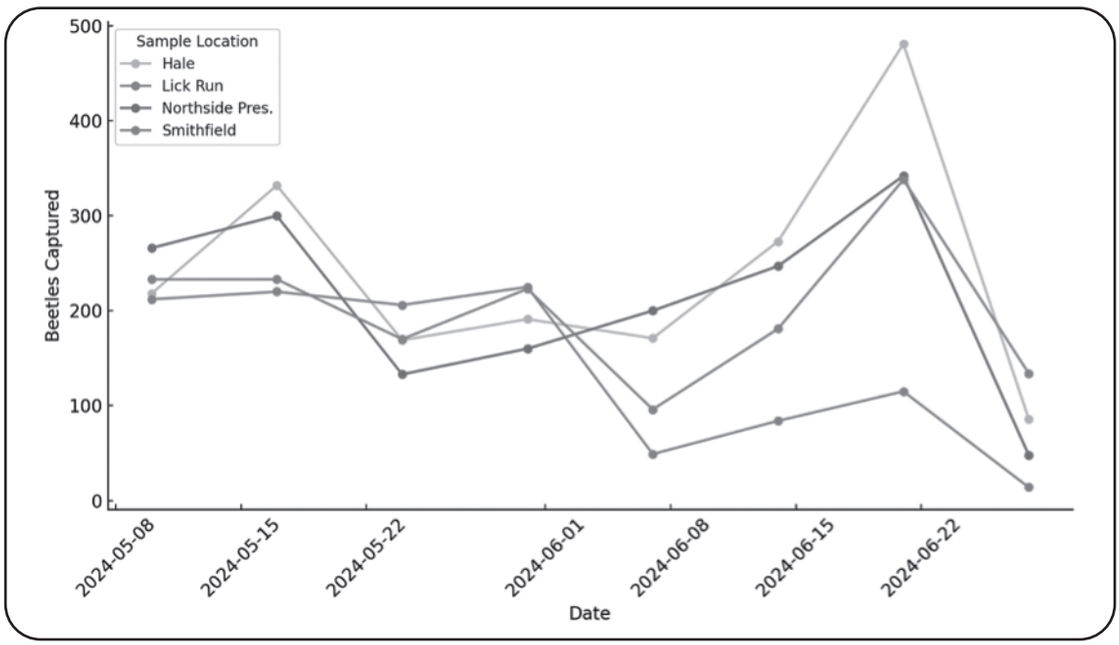
We are assembling a team of researchers and Extension specialists to meet with stakeholders to plan a project grant to best address many of these top ten pest problems. If you have an interest in pumpkins and want to take part in this either as a researcher, IPM practitioner, or grower, please contact me (tkuhar@vt.edu).

Cucurbit crops in the mid-Atlantic U.S. are attacked by several different insect species that can impact crop yield and quality. **Cucumber beetles** (*Acalymma vittatum* and *Diabrotica undecimpunctata howardi*) are usually the earliest to attack and most conspicuous pests. Adult beetles invade crops at all stages even at cotyledon, where large aggregations and their concomitant leaf feeding can kill seedling plants.

Furthermore, beetles also can transmit disease pathogens including the bacterium *Erwinia tracheiphila* which causes bacterial wilt. The bacteria overwinter in the guts of cucumber beetles. The diseases can kill many susceptible cucurbit varieties. Cucumber beetles can also carry and transmit Squash mosaic virus, which can lead to stunted plants with distorted, blotchy-colored leaves. The virus can also reduce fruit yield and make fruits malformed and blotchy in color. If that's not enough reason for concern, cucumber beetles also may feed on the rinds of fruit, causing direct damage to crops. Consequently, these insects need to be controlled on cucurbit crops for many reasons.

Most growers control cucumber beetles with neonicotinoids as either pretreatments on seeds such as such as Farmore F1400 (provides 3 weeks of protection) or make foliar applications once beetles are seen on plants -usually pyrethroids (i.e., lambda-cyhalothrin, permethrin, bifenthrin, Baythroid XL, Mustang Max, Asana XL, etc.) are used for this as they are quite efficacious and relatively cheap. This pest management approach has worked well for a few decades, but there are now a few concerns with the currently used insecticides. With regards to neonicotinoids, there are environmental safety (particularly bee toxicity) concerns, which has already led to some cancelation of neonicotinoid uses in certain states as well as

Fig. 1. Striped cucumber beetle captures at sites that received early season trapping effort by date.



end-market acceptability of produce treated with neonicotinoids. With regards to pyrethroids, these broad-spectrum insecticides have concerning non-target effects – killing beneficial organisms; which leads to outbreaks of aphids and mites. There are also some concerns of resistance - pyrethroids not working against cucumber beetles in Delaware (David Owens, University of Delaware, personal communication).

As most growers know, cucumber beetles aggregate in great numbers. This is the result of their highly acute response to semiochemicals such as the aggregation pheromone **vittatalactone**, which is emitted when overwintering male beetles encounter attractive cucurbit host plants to stimulate aggregation. This is most pronounced in the spring when and mass-attack on young cucurbit cotyledons can result in rapid destruction of plantings. Cucumber beetles are also attracted to certain floral kairomones such as Indole, and TIC: combination of Trimethoxybenzene, Indole, and trans-Cinnamaldehyde). The strong attraction of cucumber beetles to these compounds provides an opportunity for management strategies.

Determining if early season trap-out with semiochemical baited traps reduces striped cucumber beetle pressure on cucurbits

To demonstrate the potential benefits of a pheromone-based trap-out approach for small-scale local growers, we are collaborating with multiple farmers around the New River Valley. In 2024 we collected our first year's data and established 8 field sites where cucurbit crops occupied less than an acre (between 500 and 900 square meters) and beetle infestations were confirmed in the previous year. 4 sites received the trap-out treatment, and 4 served as controls. The study is divided into two phases:

Initial Trapping Phase (April - June): Baited traps were intended to capture the overwintered generation of striped cucumber beetles before competition arose from flowering cucurbits. Traps included sticky cards mounted horizontally on wooden stakes, baited with vittatalactone and indole lures. They were replaced biweekly. Beetle captures were counted weekly to assess the impact of baited traps on beetle populations.

Continued on next page

Current Research in Cucumber Beetle Management and Pumpkin Grower Survey Results (continued from page 73)

Fig. 2. Cumulative beetle captures across the early-season trapping period by field site.

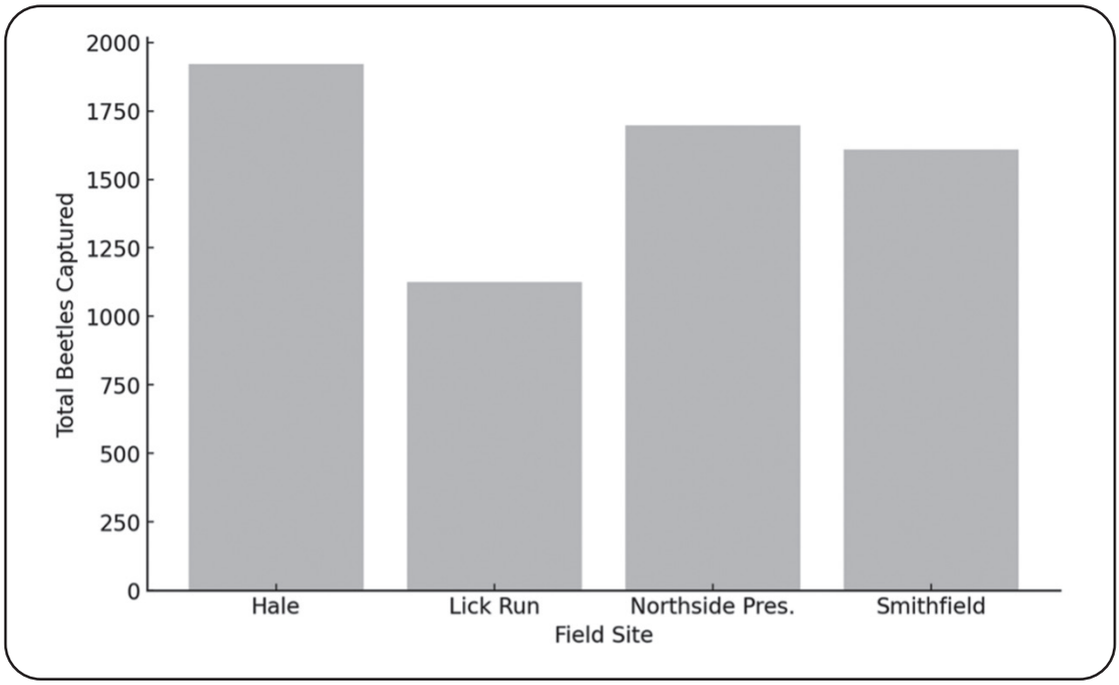
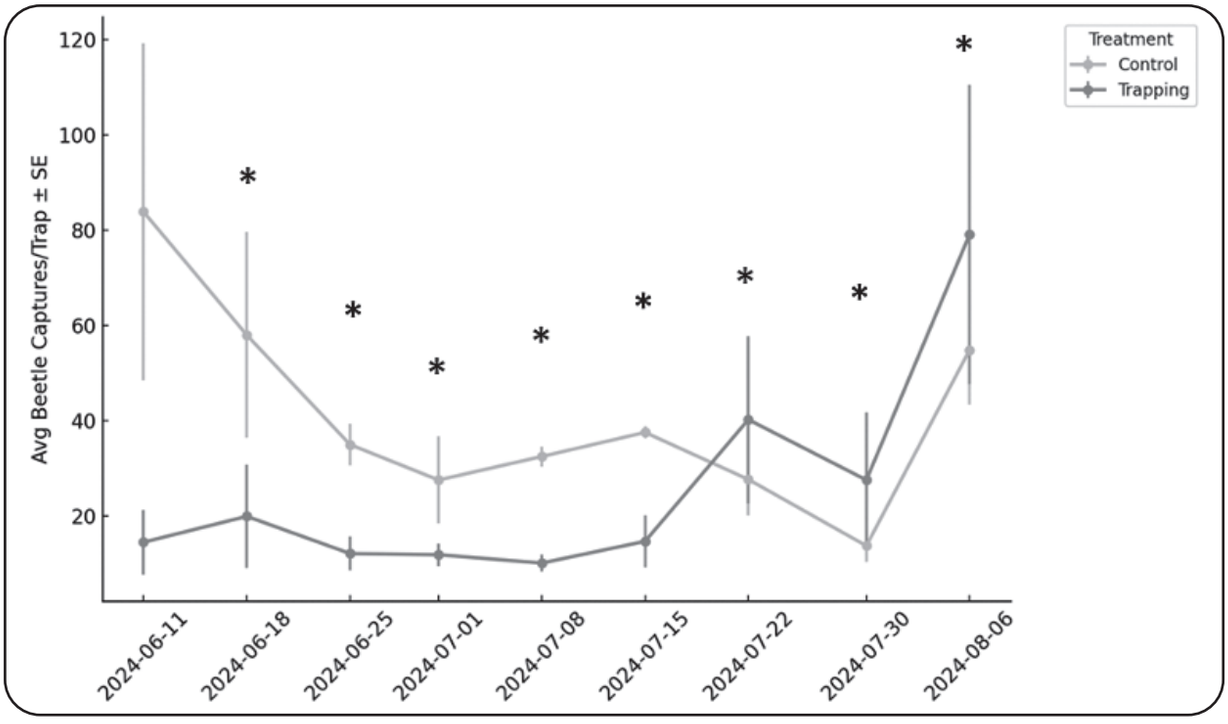


Fig. 3. Average beetle captures by treatment. Farms that received early-season trapping effort maintained lower beetle populations throughout most of the summer compared to control farms that received no trapping effort. * denotes statistical difference (P<0.05) as determined by LMER and post-hoc Tukey-HSD.



Continued on page 77

Phytophthora capsici on Pumpkin

Michigan State University
140 Plant Biology Lab | E. Lansing, MI 48824
hausbec1@msu.edu

Growers producing pumpkins have reported significant losses due to Phytophthora crown and fruit rot in recent years. Recognizing disease due to *Phytophthora capsici* is not always easy. Since the disease often occurs in the low areas of a field where water accumulates, many growers assume that when plant stunting occurs, it is due to the 'water logging' of the roots, but infection by *P. capsici* may be to blame. Squash, pumpkin, and pepper plants often have obvious disease symptoms, with plants wilting or collapsing prior to dying. Such plants often have brown to black discolored roots and crowns. The disease is easily seen on infected fruit, initially as dark, water-soaked lesions which develop a distinctive white 'powdered sugar' layer of spores on the surface of the fruit. Fruit infection is especially troublesome because the infection may occur days before the symptoms become visible. As a result, healthy-appearing fruit may be harvested, and the fruit break down during transit or on grocers' shelves.

Several control measures need to be used in a program to reduce losses from this disease. Crop rotation may reduce the number of *P. capsici* spores remaining in a field. A minimum of four years crop rotation to hosts other than those listed in Table 1 is recommended to avoid a rapid build-up of the pathogen. Crop rotation may help to lower levels in a field, but planting any of the susceptible vegetable crops in a field with a history of *P. capsici* is risky (see Table 1).

***Mary Hausbeck** is a University Distinguished Professor and Extension Specialist at Michigan State University where she focuses on pathogen detection and disease management of vegetable crops and greenhouse flower and ornamental plants. She received her PhD in plant pathology at Penn State. Her research and extension program has supported and trained many students.*

There are many fields in Michigan where this pathogen has become resistant to the commonly used fungicide, Ridomil Gold. Fungicides perform best when used early and frequently. When the weather is favorable for disease (wet and rainy), fungicides should be applied in rotation every 5 to 7 days. Growers should avoid relying on a single fungicide, to delay development of fungicide resistance with *P. capsici*. Good coverage of the fruit with the fungicide is essential. Fungicides cannot be relied upon alone to prevent disease, but they can provide an extra degree of protection when used in combination with other management practices, such as crop rotation, raised beds, and water management.

Table 1. Commonly grown vegetable crops affected by *Phytophthora capsici*.

cucumber	summer squash	bell pepper	snap bean
gourd	winter squash	hot pepper	lima bean
muskmelon/cantaloupe	watermelon	eggplant	
pumpkin	zucchini	tomato	

Continued on next page

Phytophthora capsici on Pumpkins (continued from page 75)

Top Reasons Why *Phytophthora capsici* Threatens Pumpkin Production

1. Phytophthora is favored by warm temperatures and rain.
2. Phytophthora has successfully colonized many geographical locations in many states of the U.S.
3. Fruit that appear healthy at harvest can break down during transit or on the grocers' shelves.
4. Crop resistance has not been identified in the most popular cultivars.
5. On many farms, Phytophthora has become resistant to a key fungicide used for control.
6. Pumpkins require a long maturation time and are exposed to the pathogen for an extended time.
7. Growers for the processing industry cannot invest in high-cost management practices.
8. Phytophthora has been found in irrigation ponds, a creek and a river, and may be spread readily by water.
9. Oospores of the fungus are long-lasting (10 years or more) in soils. Once soils become infested with the fungus, they are taken out of vegetable production.
10. Fungicide coverage of the fruit is hard to obtain.

Preferred Phytophthora Fungicides for WINTER SQUASH and PUMPKIN

Product	A.I.	FRAC	Comment
Elumin	ethaboxam	22	Rotate between applications. Apply as a soil or foliar spray or via drip.
Orondis Gold	oxathiapiprolin/ mefenoxam	49/4	Apply at-planting in-furrow, as a banded surface spray following transplanting or during seeding, or via drip. If applied via drip on direct-seeded crops delay application until after emergence.
Orondis Ultra	oxathiapiprolin/ mandipropamid	49/40	Rotate to a fungicide with a different FRAC after 2 sequential applications. For disease control, use either soil or foliar applications of oxathiapiprolin products, but not both.
Presidio 4SC	fluopicolide	43	Use in a fungicide tank mix. Apply via drip or as a foliar spray.
Revus 2.08SC	mandipropamid	40	Include surfactant.
Apron XL*	mefenoxam	4	Seed treatment. Wait 6 weeks after transplant to apply mefenoxam products.
Ridomil Gold SL*	mefenoxam	4	Apply as a preplant-incorporated, at-plant soil spray or via drip.

Phytophthora capsici on Pumpkins (continued from page 76)

Phytophthora 'B' Team for WINTER SQUASH and PUMPKIN

Product	A.I.	FRAC	Comment
Forum 4.18SC	dimethomorph	40	Use in a fungicide tank mix.
Gavel 75DF	mancozeb/ zoxamide	M03/22	Relatively long PHI.
Ranman 400SC	cyazofamid	21	See label about surfactant.
Zampro 4.4SC	ametoctradin/ dimethomorph	45/40	Apply via drip or as a foliar spray.

* Preplant incorporation of Ridomil Gold SL is not labeled for *Phytophthora*, it is labeled for control of *Pythium*. Ridomil Gold Bravo SC and Ridomil Gold Copper may be useful in protecting fruits from *Phytophthora* and are labeled as foliar applications for downy mildew control in cucurbits. Fungicide resistance has been detected in *Phytophthora* where mefenoxam has been used frequently.

Good drainage is important in managing this disease. Susceptible crops should be planted on well-drained sites and in raised beds. However, even plants growing on well-drained fields on raised beds may become severely diseased if rainfall is heavy.

Contamination of ponds, creeks and rivers by *P. capsici* that are used for irrigating vegetables should be of concern to growers. The pathogen has a swimming spore (zoospore) that forms when the weather is wet and moves in water, spreading to new fields. Run-off water from infested fields can carry the pathogen from diseased plants to nearby water sources used for irrigation. In Michigan, the presence of *P. capsici* in some irrigation water sources has been reported. The pathogen was frequently detected in a river, creek, and a naturally fed pond. These water sources were located near crops with symptoms of Phytophthora crown and fruit rot. Using the water from these contaminated sources to irrigate healthy crops should be avoided to limit the spread of this devastating disease.

Current Research in Cucumber Beetle Management and Pumpkin Grower Survey Results (continued from page 74)

The plots differed in their arrangements and trap counts due to the varying sizes and shapes of study locations. Nevertheless, traps were generally spaced 50 feet apart along fence edges and tree lines close to the historic cucurbit plots but without impeding farm activities. Each of the 4 experimental (trapping) sites received 7-8 baited traps containing indole and vittatalactone lures.

Monitoring Phase (June - August): Un-baited sticky traps are evenly spaced within cucurbit plots to monitor beetle presence. Four traps per plot will be replaced every two weeks, and beetles will be counted.

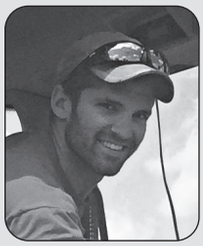
The impact of the vittatalactone-indole baited traps on beetle populations was analyzed using a linear mixed-effects model (LMER), with treatment, date, and their interaction as fixed effects, and field site as a random effect. We found significant reductions to cucumber beetle populations across the monitoring phase in trapping sites (coefficient = -69.38, SE = 14.90, $z = -4.66$, $p < 0.001$), with daily mean beetle populations in trapping sites remaining well below control sites until late July, even as baited traps were removed in June as crops blossomed. Additional field sites over a wider geographic area will be used in the 2025 field season.

Lessons from the Pumpkin Patch: Insights from U-Pick Operations

Ben Butler
Butler's Orchard
22222 Davis Mill Road | Germantown, MD 20876
Ben@ButlersOrchard.com

Butler's Orchard has had a Fall Festival and has been growing pumpkins for PYO for 45 years. There has been much evolution over the years, but this is currently how we operate.

There are four options to get a pumpkin when visiting Butler's and all are $.75/lb. Our Farm Market has a 'pumpkin yard' with a full display of jack-o-lanterns, mini, giant, heirloom and edible pumpkins as well as straw bales, mums, corn stalk bundles, and a large nicely decorated photo opportunity that often has lines. We have signage indicating names and uses for most of the pumpkins, helping customers decide what to purchase especially if they are going to use the pumpkin or squash for cooking. The second option is our PYO patch is $5 per person entry fee. We have cashiers setup with ipads running square to check in customers who bought a ticket online (ticketspice) or collect payment. Pumpkins are grown in a 2-4 acre field depending on the yearly rotation. We also have unique novelty and edible pumpkins in the grass as they enter the patch and do our best to create a wow factor of varieties and volume. In the patch we have multiple photo ops and a rustic swing. This location also has two large scales to weigh the pumpkins in our pumpkin carts without having to put them on a scale. This speeds up checkout time significantly. The third option is our 'festival pumpkin yard'. Access to this area is only with our $16-22 per person Festival admission. Similar to the other locations, we have large displays with a wide variety of options. This requires daily restock and cleanup/organization. The last option is for those who also have paid for festival admission and is a pumpkin patch for those who want to pick a pumpkin out of the field, similar to the PYO patch but it's a better environment as there are never any large crowds.



***Ben Butler** is a 35-year-old 3rd generation grower. Butler's Orchard is a family owned and operated pick-your-own farm in the suburbs of Washington D.C. They offer pick-your-own small fruit (15 acres of Blueberries), tree fruit, vegetables, cut flowers and Christmas Trees. They also have an on-farm market and a wide variety of agritainment activities throughout the year.*

Out of these four locations we generally sell over 500,000 lbs per season. We focus on keeping clean pumpkins with nice dark stems with options for every size, color and variety. We also sell cider, donuts, kettle corn, caramel apples, pies, bags of apples, and more at nearly all these locations at the checkouts and move a lot of product this way. Standard marketing basics.

We grow roughly 20-30 acres of pumpkins per year and supplement our PYO fields with pumpkins from our satellite locations. When we are out, we do purchase a large amount of pumpkins from local growers and purchase from semi-local auctions as needed.

Every operation has their own challenges and successes but what I discussed above is a winning model for us that has evolved over the years. I would be happy to discuss anyone's particular operation or questions.

Going Underground to Solve Root Crop Diseases

Mary Hausbeck
Michigan State University
140 Plant Biology Lab | East Lansing, MI 48824
hausbec1@msu.edu

Phytophthora Root Rot or Rubbery Brown Rot: Phytophthora root rot of carrot is caused by a *Phytophthora* sp., which can infect carrots in the field near harvest, with infection continuing in storage. Infected portions of the root become dark brown to black, water-soaked and rubbery in consistency. Lesions occur in one or more bands anywhere on the carrot root. White growth may develop on the lesions, which spreads the fungus to adjacent roots. As lesions expand and age, a watery soft rot may develop allowing other secondary micro-organisms to invade the root. Phytophthora sp. is associated with wet soil conditions from excessive rain/irrigation and temperatures between 70-75°F. The *Phytophthora* pathogen produces oospores which are long term survival structures that remain in the soil and zoospores (swimming spores) which are easily spread through water. Managing soil water, maintaining adequate soil drainage and avoiding prolonged periods of water saturation help to limit this pathogen. Also, maintaining optimal storage conditions, temperature at 32° F and relative humidity <95%, along with good sanitation helps to limit *Phytophthora* sp. after harvest.

Root Dieback (Pythium Brown Rot and Forking): Root dieback is caused by *Pythium* spp. and occurs wherever carrots are grown. Root dieback of carrots produces branched or stubbed roots. This fungal-like pathogen kills young tap roots after seed germination, reducing root length and/or stimulating forking. Forking and stubbing occur, but these symptoms can also be caused by soil compaction, nematodes and excessive water. The severity of the disease may be dependent on the density of *Pythium* spores in fields, in addition to wet soil conditions and large amounts of fresh carrot residue. *Pythium* spp. produce sporangia and overwintering spores (oospores) that can overwinter for long periods of time. Spores and mycelia spread the fungus in the field, which is favored by wet soils. Disease control can be achieved by avoiding excessive watering, by providing good field drainage and by planting carrots in deep, well drained soils. Rotations with small grains may reduce soil populations of some *Pythium* spp.

***Mary Hausbeck** is a University Distinguished Professor and Extension Specialist at Michigan State University where she focuses on pathogen detection and disease management of vegetable crops and greenhouse flower and ornamental plants. She received her PhD in plant pathology at Penn State. Her research and extension program has supported and trained many students.*

Crown Rot: Crown rot of carrots is caused by *Rhizoctonia solani*, a soilborne fungus with a wide host range. The fungus infects carrot roots near maturity, but it can cause damping-off of carrot seedlings. Found in many carrot production areas, crown rot is more severe on muck-grown carrots and in areas with warm temperatures and wet conditions, especially when these environmental conditions occur near harvest. Field symptoms include premature senescence and death of foliage. On carrot roots, symptoms include dark brown sunken lesions or cankers near the crown or in other parts of the root. In general, crown rot is a dry rot, but occasional invasion by soil bacteria and other fungi may induce soft rot. *R. solani* overwinters in soils as mycelia on plant debris and as dark brown

Continued on next page

Going Underground to Solve Root Crop Diseases (continued from page 79)

sclerotia that remain in soil for long periods. Infection of the crown from overwintering mycelia and germinating sclerotia may occur any time during the growing season under high moisture and temperatures >64° F. R. *solani* can spread from plant to plant in closely spaced carrots when the canopy is fully formed. Infection may continue in storage. Cultural practices that reduce crown injury and enhance soil drainage and air circulation within the canopy are recommended. Plant debris from previous crops should be removed before planting carrots, and carrots should not follow perennial crops such as alfalfa. Rotation of fields with small grains may reduce inoculum levels.

Fusarium Dry Rot: Fusarium dry rot of carrot roots is caused by *Fusarium* spp., soilborne fungi that occur wherever carrots are grown. Fusarium dry rot is commonly a carrot root disease, but the fungi can also be associated with seeds. Disease is severe on carrots held in fields after maturity and it can develop in storage. *Fusarium* spp. spores survive in soil, plant debris and crop residues and the spread of the pathogen occurs through mycelia and airborne spores. Moisture, warm temperatures and wounds caused by equipment, insects and other fungi facilitate the growth and spread of *Fusarium* spp. Symptoms of the disease include brown, leathery lesions, side cankers and crown decay. In storage, rapid growth of the fungi is favored by free moisture and temperatures between 45 and 70°F, and contamination of adjacent roots can occur quickly. Fusarium dry rot can be reduced by avoiding wounding of carrots, providing adequate storage conditions (32° F and RH< 95%) and drying the carrots before storage.

Sour Rot: Sour rot of carrot is caused by the fungus, *Geotrichum candidum*, a common soil inhabitant that infects carrots through wounds. Infection begins in the field and continues during storage. Sour rot symptoms include soft, watery, colorless decay on carrot roots. Often the surface of the decayed area is covered with dull, white spores of the pathogen and a vinegar-like odor may develop. In storage, sour rot development is enhanced when storage facilities are warmer than recommended and improperly ventilated. In the field, control of *G. candidum* is achieved with good field drainage and by minimizing wounding of carrots. In storage, good sanitation (use of new or disinfected storage containers), precooling and storing carrots at 32° F is essential.

Foliar Blights. High humidity and frequent rainfall or irrigation is common during the growing season in the eastern growing regions of the U.S. and yield-threatening foliar blights are a recurring problem. Foliar blights caused by fungi (*Alternaria dauci*, *Cercospora carotae*) and/or bacteria (*Xanthomonas campestris pv. carotae*) reduce photosynthetic area and weaken leaves and petioles. Michigan growers harvest carrots mechanically and weakened foliage can disrupt harvest due to carrot tops breaking off during lifting. In situations where foliar disease is severe and not controlled, the tops may be compromised to the extent that the crop cannot be harvested. Carrot cultivars vary in their susceptibility to Alternaria leaf blight which can be helpful in limiting the problem. To be most effective, fungicides should be applied when disease symptoms first appear with an overall management program including products with differing modes of action.

Bacterial Leaf Blight is not a yearly problem for Michigan growers. Symptoms include yellow-ringed dark blighting on leaves and roots that first appear on the underside of the leaves but can become severe. Dark streaks may form on the petioles accompanied by a sticky, yellow ooze. The bacterium can occur on the seed and can also survive in soil when there is carrot debris. It is thought that the bacteria can survive in carrot debris for one year. Once the carrot debris decomposes, the bacteria cannot survive in the soil. The bacteria spread within a field by rain or overhead irrigation. Under dry conditions,

Continued on page 83

Beating Cercospora Leaf Spot of Table Beet

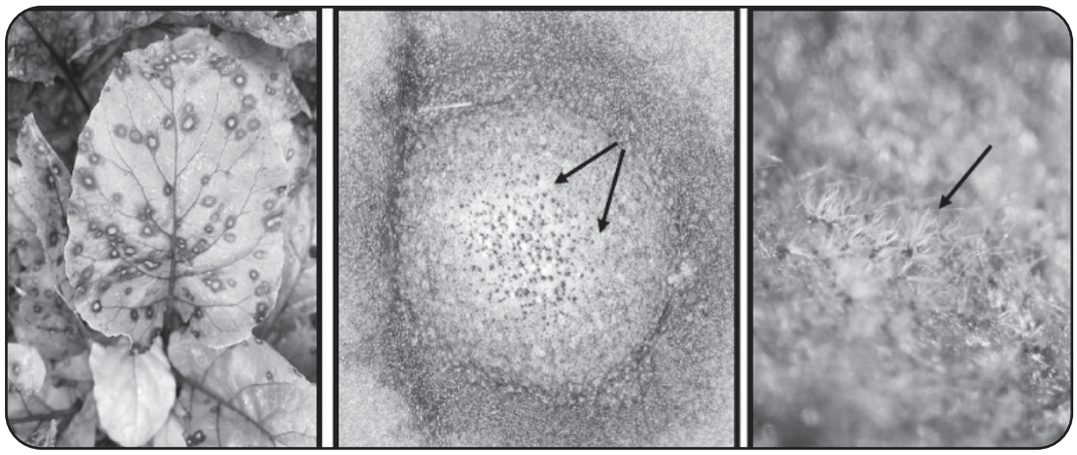
Sarah Pethybridge[1] and Julie Kikkert[2]

Sarah Pethybridge *is an Associate Professor (Plant Pathology) at Cornell AgriTech, Geneva, New York. She earned her B. Agr. Sc. (Hons) and Ph.D. in Plant Pathology from the University of Tasmania, Australia She joined Cornell University in 2014 after plant pathology roles in Australia and New Zealand. Her program focuses on the epidemiology and management of diseases affecting vegetables in conventional and organic production. She and her husband, Frank have two children, Emily and James.*

Cercospora leaf spot (CLS), caused by the fungus, Cercospora beticola, is one of the most devastating and recalcitrant diseases affecting table beet production in the Northeastern United States. For the fresh market, crop loss results from the disease lesions on the foliage, directly impacting marketability and profitability. For broadacre table beet production, insufficient and weak foliage can impede harvesting and cause economic losses as mechanical top pullers are not able to remove the roots from the ground. Symptoms of the disease begin as small, circular to oval shaped necrotic lesions with a tan to purple margin and gray center. As the disease progresses, the lesions grow together, resulting in decreased photosynthetic area (Fig. 1).

Fig. 1. Symptoms of Cercospora leaf spot caused by the fungus Cercospora beticola in table beet cv. Ruby Queen (left); pseudostromata of the fungus within the lesion marked by arrows (middle) and spores produced on the pseudostromata that are responsible for new infections also marked by an arrow (right).

As the disease progresses, the lesions spread and can cause complete defoliation, resulting in decreased photosynthetic area. High temperatures (79-89°F), relative humidity (> 90%) and prolonged leaf wetness periods (>8.5 hours) are conducive for disease spread. When the environment is conducive to infection and disease development, the fungus produces black, pin-head sized structures called pseudostromata that bear spores. These spores are responsible for disease spread within the season and are dispersed via wind and rain splash.

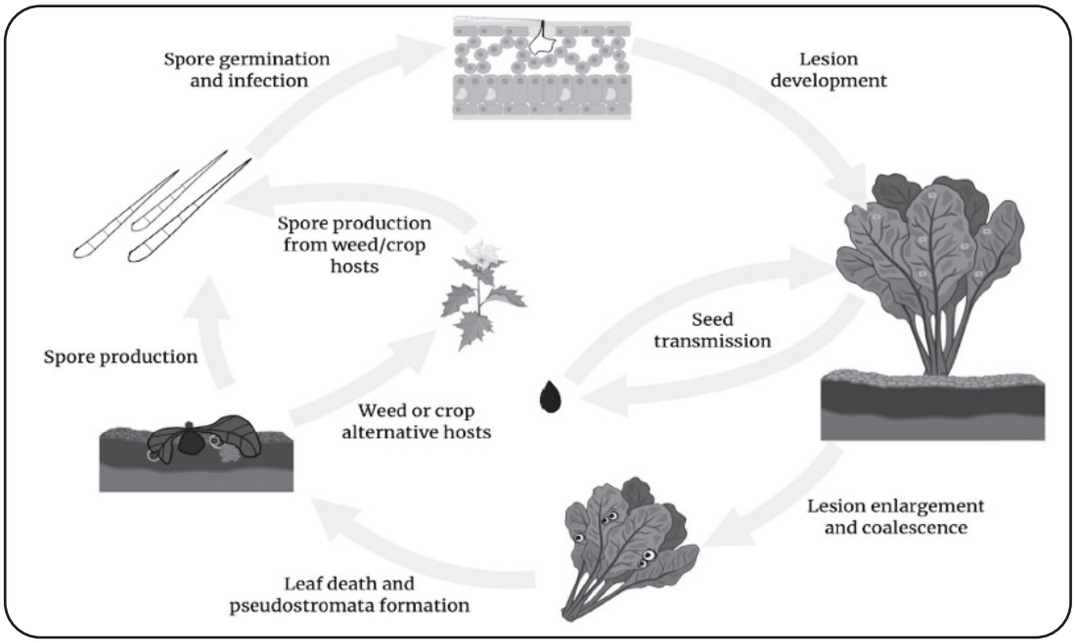


[1] Plant Pathology & Plant-Microbe Biology Section | Cornell AgriTech | Geneva, NY 14456
[2] Cornell Vegetable Program | Cornell Cooperative Extension | Canandaigua, 14424

Continued on next page

Beating Cercospora Leaf Spot of Table Beet (continued from page 81)

Fig. 2. Lifecycle of Cercospora leaf spot of table beet.



The lifecycle of the fungus also highlights the role of multiple sources of pathogen inoculum that can initiate CLS epidemics at the beginning of the season (Fig. 2) including:

- Infected seeds;
- Infested crop residue (material from previous crops that also had CLS);
- Alternative weedy hosts that can be infected by *C. beticola* including lambsquarters and pigweed; and
- Alternative crops in the vicinity that may also be infected including Swiss chard, sugar beet, and spinach.

Management

Effective CLS management therefore relies upon an integration of strategies to reduce the influence of primary inoculum to initiate infections and in-season management tactics to protect foliage from infection. Cultural practices include:

- Use of certified seeds;
- Control of alternative weeds and crop volunteers to remove green bridges for inoculum between subsequent cropping seasons;
- Crop rotation with non-host crops (i.e., those not within the Chenopodiaceae) for at least 3 years;
- Burial/incorporation of infested leaf debris into the soil soon after harvest to enhance decomposition;
- Minimizing leaf wetness by avoiding overhead irrigation. Consider drip irrigation where practical.
- Planting arrangements that decrease relative humidity and promote rapid leaf drying will reduce CLS spread but are also likely to increase root size.
- Cultivar selection. Table beet cultivars vary in their agronomic characteristics (e.g. root size, color, and shape) and susceptibility to CLS. In NY, table beet cultivars: Boldor, Detroit, Falcon, Merlin,

Rhonda, and Touchstone Gold were of similar susceptibility. Cultivar Ruby Queen was less susceptible to CLS than these cultivars. Check the latest data from your seed supplier for information on cultivar susceptibility.

Beating Cercospora Leaf Spot of Table Beet (continued from page 82)

In-season control - fungicides

Fungicides are commonly used in conventional and organic table beet production for CLS control.

Conventional fungicides. Fungicides significantly increase foliar health and extend leaf survival, but in most cases, do not significantly affect the dry weight of roots and root shoulder diameter. Preventative application of protectant fungicides prior to infection and symptom development can provide the best results. Resistance of *C. beticola* isolates has been reported to some fungicides with single-site modes of action, including strobilurin fungicides (FRAC 11) like **Quadris** (azoxystrobin). Demethylation inhibitor fungicides (FRAC 3) have variable efficacy. For example, **Tilt** (propiconazole) provides moderate CLS control. However, **Cevya** (mefentrifluconazole) is a newer generation active ingredient compared to the propiconazole in Tilt and provides superior disease control. **Miravis Prime** (pydiflumetofen (FRAC 7) + fludioxonil (FRAC 12)), is a highly effective fungicide for CLS control in production areas of high risk of CLS. Alternating fungicides with different modes of action is important to preserve the efficacy of fungicides. Merivon (fluxapyroxad (FRAC 7) + pyraclostrobin (FRAC 11)), Luna Tranquility (fluopyram (FRAC 7) + pyrimethanil (FRAC 9)) also have some efficacy for CLS control and offer some rotational options with Tilt and Miravis Prime.

In our NY trials, Cevya and Miravis Prime are currently the most effective conventional fungicides for CLS control.

*OMRI-listed fungicides. T*here are also a range of efficacious products registered for the control of CLS in organic table beet production. A tank mix of Cueva (copper octanoate; FRAC M 01) and Double Nickel LC resulted in significantly improved disease control in comparison to either product alone, and disease control was equivalent to conventional fungicides. LifeGard (*Bacillus mycoides* isolate J; FRAC 06) has also provided similar CLS control to Cueva + Double Nickel, when applied for the first time in the season 24-48 hours prior to infection.

Acknowledgments. We are grateful for cooperation and support from Seneca Foods and the New York Vegetable Research Association and Council.

Going Underground to Solve Root Crop Diseases (continued from page 80)

low levels of seed contamination may not result in significant disease and crop loss. However, under hot and wet conditions, even a low level of seed contamination may result in high levels of bacterial blight. It is critical that all carrot seed be assayed for the bacterium and undergo hot water treatment if the bacterium is found. Fields with bacterial blight should be worked under as soon as the crop is harvested so that the carrot debris can decompose rapidly and therefore not allow the bacterium to survive in the soil for an extended period.

Symptoms of **Alternaria leaf spot** include dark brown/black spots with yellow margins appearing on older leaves. Severe disease results in weak petioles or defoliation. Symptoms of **Cercospora leaf spot** include small circular brown spots which rapidly enlarge, accompanied by yellow/red discoloration on younger leaves and girdled petioles, resulting in defoliation. Alternaria and Cercospora may occur together and are managed similarly. Methods to reduce disease pressure include planting disease-free seed, following a 2-year crop rotation, minimizing overhead irrigation during warm weather, and applying fungicides. Methods to effectively schedule fungicide applications according to field scouting and the TOMCAST disease forecasting system have been developed and have been adopted by many growers.

Small Scale Potatoes, Large Scale Profits

Art King | Harvest Valley Farms

Normally you would not think that potatoes would be a high demand item, but they are. Yes, you can buy them really cheap in some places, but those are mostly sprayed with a sprout inhibitor and are somewhat beat up from the automation. The key to profitable potatoes is to grow the varieties that taste the best or are more nutritious. Here are the varieties we grow:

- Red Norland
- Red Thumb
- Yukon Gem
- Russet
- German butterball
- Purple Majesty
- Kennebec

We plant both in black plastic or with a single row planter in the soil. Red Norland or Red Thumb is a good first early variety that we plant both in plastic and in the soil. If we use degradable plastic we can still dig with the digger if we want. The plastic is cut with the discs on the digger and flows through the digger pretty evenly. We also dig the first early ones by hand because they skin off too much with the digger. We space the seeds at 12 inches on a single row in plastic or 8" with the planter.

We dig our potatoes with a digger that just puts them on top of the soil, then they are picked up by hand. Usually, we dump them into bins and they are either stored or taken right to the packing building where we have a bin dumper into the wash line where they are cleaned and sorted.

Almost all of our potatoes are sold in quart boxes. On holidays we have sold some in 4-quart baskets. We like to do mixed quart boxes of purple, white, and red because they sell very well.

At the farmers markets we sell the quarts for 5.00 and at our farmers market for 2.99 to 4.99. So that works out to 75.00 to 125.00 per bushel. The best-selling points for our potatoes are: Never sprayed with a sprout inhibitor, lots of variety, some unusual varieties, the health benefits of buying our potatoes. Here is the information I provide to our customers:

Potatoes

Potatoes were introduced outside the Andes region four centuries ago, and have become an integral part of much of the world's cuisine. It is the world's fourth-largest food crop, following rice, wheat and maize. The purple look very nice on the dinner plate. White potatoes are best for mashing and baking.

Some of the starch in potatoes is resistant to digestion by enzymes in the stomach and small intestine, and so reaches the large intestine essentially intact. This resistant starch is considered to have similar physiological effects and health benefits as fiber: It provides bulk, offers protection against colon cancer, improves glucose tolerance and insulin sensitivity, lowers plasma cholesterol and triglyceride concentrations, increases satiety, and possibly even reduces fat storage.

Potatoes turn green when exposed to light, so always keep them in the dark. About 50 degrees is a good temperature to keep them at. They keep about 2 months at 50 degrees or 2 weeks in the pantry. Keep in mind that our potatoes are not sprayed with an "anti-sprout chemical", so they sprout faster than store bought potatoes. Not a problem, just snap the sprouts off and use them, even if they are wilted.

Root C

Unpredictable Springs: Frost Protection for Strawberries

Kathy Demchak
Dept. of Plant Science | Penn State University
102 Tyson Bldg | University Park, PA 16802
efz@psu.edu

In recent years, warm spells have occurred over the winter and into early spring that advanced plant growth. These warm spells were often followed by colder temperatures as the plants approached bloom. Plants then remained at this stage for days or weeks, resulting in many nights of frost protection being required. We've even seen frost damage on raspberries, which rarely bloom until the risk of frost is well past.

Lately we've also experienced advective freezes caused by the movement of cold air into an area and windy conditions. These freezes are more difficult to protect against than our traditional radiational frosts, which are the ones that occur on calm clear nights.

What's the Temperature Out There?

The air temperature reported from weather stations is typically measured at a height of 4 to 6' by a sensor shielded from the sun and rain. Temperatures at ground level in an open field will be several degrees colder, and maybe colder than the location where you check your thermometer, so be sure to compare the two before a frost event requiring protection happens so you can compensate for the difference.

Many kinds of devices can be used for temperature measurement, but all should be checked to make sure they are accurate at 32 degrees. Do this by placing the sensor - glass bulb, tip of a probe, etc. - in a slurry of crushed ice and water (if waterproof) while gently stirring. If using a liquid-in-glass min-max thermometer, the bulb is likely at the top of the thermometer, so make sure the bulb is immersed.

Some devices provide extra digits in their readings, but this doesn't guarantee that the device is accurate. It might just be giving you an incorrect reading very precisely.

***Kathy Demchak** has been at Penn State since 1983, working in berry crop research and extension since 1992. Prior to working with berry crops, she worked with vegetable and tree fruit nutrition and on strip-mine reclamation, all of which provided valuable experiences and many opportunities to learn. Her favorite part of her job has been getting to know the berry growers and her co-workers. She earned a B.S. in Horticulture from Penn State and an M.S. in Horticulture from Virginia Tech.*

Weather Terms – Practically Speaking

Air temperature is what it sounds like and is also called the *dry-bulb temperature*. The wet-bulb temperature can also be measured if a wet fabric covers the bulb and is exposed to air flow. It accounts for cooling from evaporation, and mirrors the temperature of the plants if they are wet. Overhead irrigation used alone for frost protection should be operating by the time that the wet bulb temperature equals the critical temperature. Wet bulb and dry bulb temperatures together can be used to calculate the relative humidity. Temperatures drop faster when the humidity is low.

The *dew point* is the temperature at which condensation occurs. It is lower when the air is dry (i.e., relative humidity is low). Water vapor condensing gives off heat, so the temperature often (but not always) stops dropping once the dew point is reached. If the dew point is below freezing, temperatures can drop to damaging

Continued on next page

Unpredictable Springs: Frost Protection for Strawberries (continued from page 85)

levels rapidly without frost forming, so you may experience a “black frost” which can catch you off-guard. A lack of white frost crystals does not mean that the temperature is above freezing.

Wind speeds of more than a few miles per hour make frost protection difficult or impossible, especially in an advective freeze. Winds disturb the pattern of overhead irrigation, but also make water evaporate faster resulting in a cooling effect. Light breezes tend to mix the air and can increase temperatures at ground level in the case of radiational frosts. Temperatures are more uniform over a larger area when it’s windy.

Sky cover refers to how much of the sky is blocked by clouds. Clouds help to block heat from radiating out into space, so they help to prevent radiational frosts, but won’t make much difference with an advective freeze.

Frost Protection Choices

Heating or burning is an old method of frost protection but is rarely used these days.

Wind machines mix the air work if a temperature inversion occurs (warm air present above a cold layer) but only work if there is no wind, provide a few degrees of protection at most, and are used more frequently for taller crops.

Floating row covers work best for small acreages of low-growing crops. Stiffer fabrics that float instead of limp ones that get matted down work provide more air space and insulation. If frost is forecast, row covers should be pulled on by mid-afternoon to allow heat buildup under them, though little may accumulate on cloudy windy days. A double layer of a 0.9 oz/yd2 or heavier row cover, even if the lower layer has a few holes, can get a strawberry crop through most frost events and works better than a single layer, especially if it’s windy. Our research plots have remained protected at temperatures as low as 21 degrees this way. Row covers should be pulled off afterward the frost event if over to minimize diseases and avoid advancing the crop.

Overhead sprinkler irrigation works because water gives off heat when it freezes, but 7 times as much water must be freezing as is evaporating for this to work. Application must be started early to allow for the temperature drop that will occur at first from evaporation. A common recommendation is to start the system when the temperature at plant level falls to 4° F above the critical temperature (for example, 34° F for open strawberry blossoms). Under conditions with wind or low humidity, temperatures may drop more than this. This is why the wet bulb temperature is a better indicator of when to start the irrigation system than the dry bulb temperature.

Most overhead sprinkler systems are designed to deliver 0.1 to 0.2 inches of water per hour and are useful for radiant freeze or frost protection when the wind is light and temperatures are at or above the mid-20s. If it’s windier or colder than that, you will need a higher application rate.

The irrigation rate can be determined by placing several straight-sided cans or buckets in the field, running the irrigation for at least an hour, and measuring the depth in each bucket. You may need to pour buckets together to get a measurable depth. If you vhrvk each bucket before pouring them together, you can tell how even your wetting pattern is.

Overhead sprinklers should be set up in a staggered pattern rather than a square one, as this results in a more consistent pattern of water application. There should be at least 50% overlap in sprinkler patterns (i.e., the sprinkler spacing should be 50% of the wetted diameter). If this pattern is used, nearly all areas of the field will be covered by 3 different sprinklers, providing backup if a sprinkler head becomes clogged.

Row covers plus overhead. Pipes and sprinklers can be set up on top of the row covers, and the irrigation started after the temperature under the row covers drops near the critical temperature. This is the safest way to protect crops in the case of advective freezes, and greatly reduces the

Unpredictable Springs: Frost Protection for Strawberries (continued from page 86)

Critical temperatures

Strawberries	Critical temp. (°F)	Blueberries	Critical temp. (°F)	Blackberries	Critical temp. (°F)
Bud emergence	10	Bud swell	15-20		
Tight bud	22	Tight cluster	18-23	Tight bud	27
"Popcorn"	26	Flower separation	22-25	Flower sepals open	29
Open blossom	30	Late closed blossom	25-26	Open blossom	30
Green fruit	28	Open blossom	27		
		Petal fall	28		

Sources: K. Perry and B.C. Poling, North Carolina State Univ.; Richard Funt, Ohio State Univ.; Michelle Warmund, Univ. of Missouri.

amount of water used regardless of the type of frost event. Because of the necessity of and time required for removing and re-applying the row covers (they can just be gathered into the row middles in which the irrigation pipes are located), this method is best suited for small acreage plantings. Uncover the plants as early in the day as possible so the foliage can dry, and pollination can take place.

What Works Best in Different Scenarios

Regardless of production system and crop: *Site selection* is an important factor. Cold air is heavier than warm air and temperatures are often 4° to 5° F warmer at the tops of slopes, while cold air collects in the lower areas (frost pockets). Even a 10 or 20' height difference can be noticeable. Southern slopes are warmer than those facing north, but plants on Southern slopes come out of dormancy earlier, possibly negating this benefit. *Soil moisture and ground cover* can also make a difference. Moist soil holds more heat and radiates it back to the environment for a longer time than dry soil, so plantings can be irrigated a day or two ahead of an expected cold snap to allow time for heat to be captured. A bare, undisturbed moist soil with no ground cover releases more heat compared to a sod-, grass-, or straw mulch-covered soil. All of the above are more likely to make a difference during radiational frosts but have little effect in advective freezes.

Strawberries, regardless of frost or freeze type: With matted-row strawberries, leaving straw mulch on as long as possible (until the plants begin to grow) can keep the soil cold and delay plant growth to avoid some frost events.

Strawberries, radiational frosts close to critical temperature: Single or double layer of row cover or overhead irrigation.

Strawberries, radiational frosts with low temperatures or advective freezes: Double layer of row cover, or overhead irrigation overtop of single layer of row cover. The irrigation does not need to be turned on until the temperature under the row cover is approaching the critical temperature.

Blueberries and brambles, radiational frost near critical temperature: Overhead irrigation.

Blueberries and brambles, radiational frost with very low temperatures: Overhead irrigation with high water volume.

Blueberries and brambles, advective freeze: Doing nothing may be your best bet. Row covers over tall crops do little unless the row cover is very heavy like a nursery foam cover and are impossible to keep on if it is windy.

Favorite Blueberry Varieties and Production Tips

Ben Butler
Butler's Orchard
22222 Davis Mill Road | Germantown, MD 20876
Ben@ButlersOrchard.com

Butler's Orchard has been growing blueberries since 1983 and is currently producing 15 acres of mid to hill chill highbush blueberries.

Current successful varieties include Duke, Blueray, Bluecrop, with more context needed for Blueetta, Draper, Spartan.

As we all know, pH is of the upmost importance along with tissue/soil sampling to have a fine tuned fertility program. Annual pruning for us is an annual requirement. Bumblebees are brought in for pollination. Weed management is our biggest challenge and we have a trial on landscape fabric. Bird damage is a consistent issue but our crop protection program is not overly aggressive and there are no major issues with diseases or insects. We do apply aged woodchips bi-annually and have an OM content of 23% in some of the older fields.

***Ben Butler** is a 35-year-old 3rd generation grower. Butler's Orchard is a family owned and operated pick-your-own farm in the suburbs of Washington D.C. They offer pick-your-own small fruit (15 acres of Blueberries), tree fruit, vegetables, cut flowers and Christmas Trees. They also have an on-farm market and a wide variety of agritainment activities throughout the year.*

Crown and Root Rots in Strawberries: What's Normal and What's Not

Leah Fronk
Penn State Extension
Courthouse Annex | 30 North Main Street | PO Box 147
Mifflintown, Pennsylvania 17059-0147
lxf339@psu.edu

Kathy Demchak
Dept. of Plant Science | Penn State University
102 Tyson Bldg. | University Park, PA 16802
efz@psu.edu

***Leah Fronk** is a commercial horticulture Extension Educator based in Juniata County. She holds a bachelor's degree in Horticulture from Temple University and an MS in Horticulture from Penn State. Her programming focuses on organic and conventional pest management for vegetable and small fruit crops, as well as assisting growers with issues related to pesticide safety and the Food Safety Modernization Act (FSMA).*

***Kathy Demchak** has been at Penn State since 1983, working in berry crop research and extension since 1992. Prior to working with berry crops, she worked with vegetable and tree fruit nutrition and on strip-mine reclamation, all of which provided valuable experiences and many opportunities to learn. Her favorite part of her job has been getting to know the berry growers and her co-workers. She earned a B.S. in Horticulture from Penn State and an M.S. in Horticulture from Virginia Tech*

When roots and crowns are not healthy, you may notice above-ground symptoms first. This includes wilting during the day with possible recovery overnight, reduced vigor, small berries, and poor runner development. Plant growth will be reduced, but often the problem is not noticed until the plants collapse and die, usually during the stress of fruit production in the spring. All of this occurs because the plant simply cannot move nutrients, water and carbohydrates around like it can when it is healthy.

To make a diagnosis, plants must be dug up carefully to examine their crown and root system, keeping as much of the root system intact as possible. It is generally best to do this when you first suspect that there is a problem, and always before the plants are completely dead.

What's Normal?

Young healthy crowns and new primary roots will be white or cream colored throughout when first cut and feel firm. Once the crown is cut open and exposed to air, it will quickly darken (like cut apples would), at first becoming more golden in tone and then reddish-brown.

New primary (aka "peg") roots emerge from the crown as it grows taller. These primary roots grow many lighter-colored secondary ("feeder") roots when healthy that live for 1 to 2 years.

Continued on next page

Crown and Root Rots in Strawberries: What's Normal and What's Not (continued from page 89)

Feeder roots will also continue to be produced from older roots.

It's normal for the surface of older roots to darken as the roots age as a protective waxy layer is formed. This dark surface is seen on older roots on plants being carried over in the plasticulture planting, and on mother plants in matted-row plantings. Eventually, however, entire older primary and secondary roots will turn brown and die, as feeder roots normally only live for 1 or 2 years, and primary roots for 2 or 3. On plants that are several years old, eventually, the lower portions of the crown will also turn brown and die.

In matted row plantings at renovation, where soil is thrown up around the crown, the root system is renewed as new roots grow out above the old ones. In plasticulture, the plant is dependent solely on primary roots that are aging if the planting is being carried over.

Roots grow best in the 50- to 60-degree F range in the spring and fall. They stop growing during winter and harvest, and nearly so if the soil temperature is above 86 degrees. Because of this, there may be times of the year when no new primary roots are being produced. However, it should still be possible to find many fine roots on the plant.

What's Not Normal?

Crowns and roots on plants that are unhealthy will show a brown or reddish-brown discoloration. In many cases, it is possible to see that the tissue is being invaded with discoloration appearing to travel from the crown to the roots, or vice versa. There will often be an acute change in color from healthy disease to infected tissue, or there may be a water-soaked appearance to the tissue. Discoloration is often, but not always, asymmetrical. Sometimes it is apparent that the invasion is taking place where soil is getting into the crown area as in some cases of Phytophthora crown rot, or through a branch crown or root.

When the environment causes problems, as in the case of winter injury or high soluble salts in the soil, a connection to other plant parts where invasions are taking place usually isn't apparent.

Crowns of dead plants are typically a dark reddish-brown and completely dead roots turn black. Once entirely dead, there will be no difference in appearance whether the cause of death was a disease organism, severe winter injury, an herbicide application error, or severe drought and heat stress.

When attempting to diagnose problems, for the reasons mentioned above regarding root appearance as roots age, it is often helpful to find young roots and determine if discoloration can be seen on them rather than trying to diagnose the problem on older roots.

Diseases listed below, insect feeding, and winter injury can damage strawberry roots and crowns.

Red Stele, *Phytophthora fragariae*. Red stele is caused by a soil-borne phytophthora species and is more common in low spots and wet areas. As indicated by its name, when roots are cut lengthwise, the core (stele) of the root is red.

Roots grow best in the 50- to 60-degree F range in the spring and fall. They stop growing during winter and harvest, and nearly so if the soil temperature is above 86 degrees.

Crown and Root Rots in Strawberries: What's Normal and What's Not (continued from page 90)

"Rat-tail" roots are a diagnostic characteristic of red stele. As the disease progresses, fine, lateral roots may be missing, and larger, primary roots may be rotted from tip back. The red stele fungus can persist as a dormant spore for many years in soil. In wet soil conditions, the fungus grows through the roots and produces spores which can then swim to infect healthy roots in the field. If the soil stays saturated, the disease process can repeat itself. Varieties are available with varying levels of resistance to red stele. If the issue occurs every year, the use of Actigard early and regularly before the onset of symptoms may be beneficial. Ridomil and Aliette or Phostrol aid in managing red stele.

Black Root Rot (BRR), Disease complex of *Rhizoctonia* spp., *Pythium* spp., other fungi and lesion nematode, *Pratylenchus penetrans*. A disease complex means that several different organisms can be responsible for the disease. BRR is more common in older plantings or replanted fields. Also, fields that are already experiencing stress from wet soils, drought conditions, and poor fertility are more susceptible to BRR. When examining the field, an uneven "patchy" appearance can be seen. Feeder roots decay and primary roots blacken and deteriorate allowing for the outer root surface to slough off and leave a white core. Dark brown lesions may be observed on healthy roots as they begin to decline. BRR can be managed by rotating a field out of strawberries for 4-5 years, using raised beds and planting in well-drained soils with high organic matter content. No fungicides are currently recommended for control, but some growers have found success using beneficial bacteria dips prior to transplanting.

Phytophthora crown and root rot, *Phytophthora cactorum*. Phytophthora crown and root rot is caused by a different fungal species than red stele. It is becoming more common perhaps due to varietal susceptibility. Symptoms first appear as stunting or wilting of plants. Eventually, the plant will collapse, and the crown will appear red or cinnamon-colored when cut. Plants infected with phytophthora crown rot may break off completely from the crown when pulled for sampling. The disease may begin in low-lying areas of the field, or in a scattered pattern if the disease was brought in from nursery stock.

Continued on next page

Crown and Root Rots in Strawberries: What's Normal and What's Not (continued from page 91)

Management strategies for phytophthora crown and root rot include avoiding varieties that are known to be susceptible including 'Flavorfest' and 'Sweet Charlie' in fields that were planted to strawberries in the past 5 years. As with red stele, the use of Actigard in fields where phytophthora is an issue each year may be beneficial. It must be applied at the lowest labeled dose to minimize its impact on yield. Also, use a plant dip of fosetyl-A1 or a phosphite product at the time of planting.

Neopestalotiopsis. This is a new disease that can cause crown rot, leaf spot, and fruit rot. The first symptoms are seen on the leaves and appear as tan to brown V-shaped lesions that are wider at the edge of the leaf, or large tan spots. The disease can invade the crown and kill the plant, causing fruit rot symptoms like anthracnose fruit rot. Crowns, when cut, appear more brown than red when infected with Neopestalotiopsis. Outbreaks of Neopestalotiopsis have been associated with prolonged rainfall events, while disease pressure is low under dry weather conditions. Much of the research thus far has been done in Florida and shows that sprays of thiram and Switch 7-10 days apart can reduce the disease by about 40%, with certain category 3 fungicides (Rhyme, Tilt, Inspire) also having some effectiveness.

Anthracnose Crown Rot, *Colletotrichum gloeosporioides*. Anthracnose is mainly a problem in rainy, warm seasons and especially troublesome in plasticulture production systems with susceptible varieties such as 'Chandler.' The first symptom of anthracnose crown rot is that plug plants fail to grow follow transplanting. However, symptoms are often not apparent until the plants collapse or die, usually in the fall or spring following transplanting during warm weather. When the crown is cut lengthwise, a reddish-brown color can be found. The primary source of infection is thought to be from infected nursery stock, though weeds and infected plant debris can harbor inoculum in fields. Mulching with straw, even in plasticulture systems, can decrease the spread of the disease because it helps to reduce rain splash off the plastic. Fungicide recommendations are tricky because of resistance concerns. Do not apply the same FRAC code, except for captan and thiram, more than twice in one season for resistance management purposes. Growers should consult the most recent edition of the Mid-Atlantic Commercial Vegetable Production Recommendations for guidance.

Verticillium Wilt, *Verticillium dahliae*. Verticillium is a fungus that can be found in many soils especially those that previously grew tomatoes, potatoes, eggplant, and pepper. Weeds such as pigweed, horsenettle, and lambsquarters can also host the fungus. Infection is a threat especially when new plantings are established, and disease distribution may appear scattered in the field. The fungus infects the vascular tissue of plants and blocks water flow causing plants to wilt and die. A distinguishing symptom of verticillium wilt is that often the center-most leaves remain green and turgid while the outer leaves wilt and dry. Planting verticillium-resistant strawberry varieties and using a 3-5 year rotation in fields avoiding all verticillium-susceptible crops is recommended. No fungicides are currently recommended for control.

Winter Injury. Winter injury is one of the factors that can result in development of the black root rot complex. Symptoms are seen in late winter or early spring when the plants begin growing. Discoloration in the central crown area ranges from brown flecking to reddish-brown discoloration. If over half of the crown tissue is affected, yields will be reduced, but plants may recover and yield nearly normally otherwise. To reduce winter injury, adequate and timely straw mulch or row cover application is important. Raised beds are more susceptible to winter injury, but often the benefits of raised beds outweigh the risk.

Determining Why Blueberry Pollination Lacks Adaptability

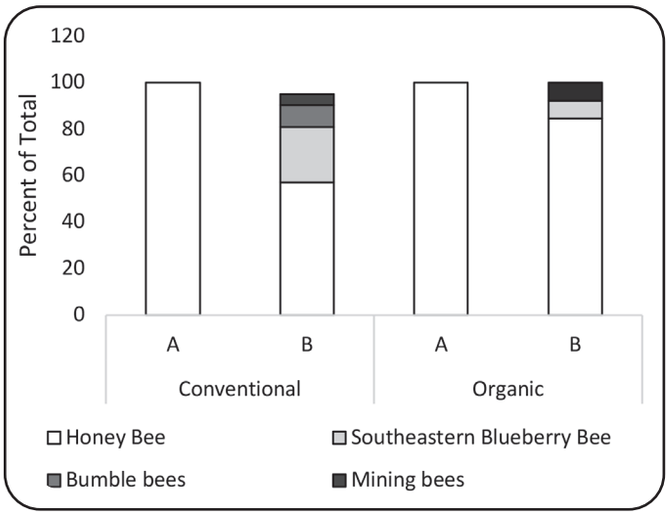
Beth Ferguson and Cesar Rodriguez-Saona
Rutgers University-Department of Entomology, New Brunswick, NJ

Blueberries are a pollinator-dependent crop that need pollen to be moved between varieties to achieve maximum yields. If there is not enough pollen deposited, the resulting fruit may be small and unfit for market. In the mid-Atlantic region, pollination can be limited resulting in low fruit set, smaller than average berries, and later-ripening berries which all result in economic losses. In New Jersey, pollination depends heavily on commercial honey bees, but there has been little recent work assessing how well this service is functioning and if the guidelines for stocking rates, arrival of hives, etc. are known and being actively followed. Provided here are initial results of a two-year assessment of blueberry pollination in New Jersey in conventional and organic farms. The pollinator community foraging on blueberries was assessed as well as the weight and seeds present in the berries. The pollinator community was dominated by honey bees at all farms, and indications of pollination limitation in the second year was present on all farms sampled.

Beth Ferguson *is a post-doctoral researcher at Rutgers University, where she is conducting studies on pollinator-blueberry interactions. She obtained her Ph.D. from University of Arkansas and worked as a post-doctoral fellow at the USDA ARS Northern Crop Science Lab in Fargo, North Dakota.*

Cesar Rodriguez-Saona *is a Professor and Extension Specialist in the Department of Entomology at Rutgers University, where he conducts basic and applied research on the development and implementation of sustainable insect pest management practices and delivers educational information to growers. He received his M.S. from Oregon State University and his Ph.D. from the University of California, Riverside.*

Fig. 1. Percent of bee species collected in two conventional and organic farms in New Jersey in 2023.



Bloom Characteristics

It is not just movement of pollen, but the number of pollen grains successfully deposited that determine if a fruit is produced and its size. As the number of mature seeds produced in a berry increase, the weight also increases. While honey bees are the primary pollinator, they move less pollen during a visit than other bees (southeastern blueberry bee, bumble bees, mining bees) and require 3 times more visits than bumble bees to successfully pollinate a flower. Flowers are also only viable for 3-5 days and are most receptive to pollen within the first couple of days and then decreasing over time.

Continued on next page

Determining Why Blueberry Pollination Lacks Adaptability (continued from page 93)

Factors Impacting Pollinator Foraging

Aspects of weather including temperature, cloud cover, wind, and rain all influence bee foraging. Blueberries bloom early in spring when weather is highly variable. In particular, honey bees forage under the following conditions: greater than 50°F, partially cloudy to sunny, wind speeds less than 10-12mph, and no rain. Bumble bees are more adaptable to less predictable conditions and forage at 45°F, heavy cloud cover, mist and light rain, and winds up to 15-18mph. Honey bees and native bees are also most active at different times of day, with larger bees most active in the morning and evening and honey bees most active in the afternoon.

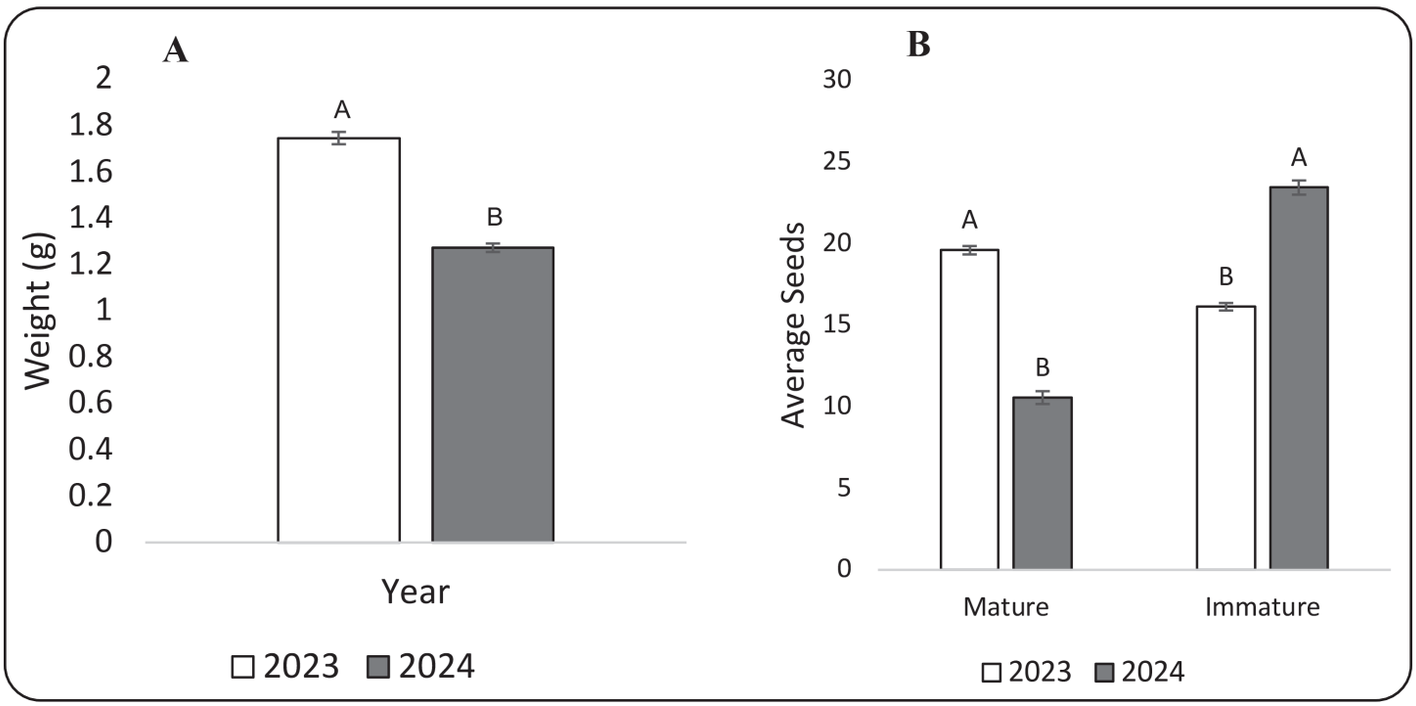
Pollinators of Blueberry

Previous surveys of bees in New Jersey found 34 wild bee species in addition to honey bees. Our collections in conventional farms identified 4 wild bee species, and 2 in organic. Honey bees made up the bulk of bees collected with 57.1% and 100% in conventional and 84.6% and 100% in organic (Fig. 1). The second most-common species on farms where honey bees were not the only bee collected was the southeastern blueberry bee at 23.9% in conventional and 7.7% in organic. The number of species present varies between farms and is likely influenced by the surrounding habitat.

Evidence of Pollination Limitation

In the first year, weather conditions in New Jersey were considered favorable for honey bee foraging, but in the second year there were more cold, overcast, and rainy days. When comparing the average weight per berry (in grams), berries were heavier by about half a gram in the first year (Fig. 2A). The number of mature seeds (successfully pollinated) was also greater in the first year, with nearly twice as many as in the second year (Fig. 2B).

Fig. 2. Weight (A) and seed counts (B) per blueberry fruit in 2023 and 2024. Different letters indicate significant differences.



Determining Why Blueberry Pollination Lacks Adaptability (continued from page 94)

Recommendations

In New Jersey, the wild pollinators present in and around blueberry farms do not contribute significantly to pollination. Because honey bees are the primary pollinator, when weather does not permit foraging, little pollination is actively occurring. Growers should consider incorporating commercial bumble bees in the short term to complement the existing honey bee pollination.

Acknowledgements. Financial support for this project was provided by the NJ Blueberry Research Council and the John and Anne Gerwig Director's Fund for Rutgers Cooperative Extension. We thank the NJ blueberry growers for providing field sites and Jack Collins and Max Leavitt-Shaffer for field assistance.

References

Benjamin, F. E. and R. Winfree. 2014. Lack of pollinators limits fruit production in commercial blueberry (*Vaccinium corymbosum*). Environmental Entomology 43 (6): 1574-1583

Javorek, S. K., K. E. Mackenzie, S. P. Vander Kloet. 2002. Comparative pollination effectiveness among bees (Hymenoptera: Apoidea) on lowbush blueberry (Ericaceae: *Vaccinium angustifolium*). Annals of the Entomological Society of America 95(3): 345-351

Nicholson, C. C., and T. H. Ricketts. 2019. Wild pollinators improve production, uniformity, and timing of blueberry crops. Agriculture, Ecosystems and Environment 272: 29-37

Rogers, S. R., D. R. Tarpy, H. J. Burrack. 2014. Bee species diversity enhances productivity and stability in a perennial crop. PLoS ONE 9(5): e97307

Sanderson, R. A., L. A. Goffe, and C. Leifert. 2015. Time-series models to quantify short-term effects of meteorological conditions on bumblebee forager activity in agricultural landscapes. Agricultural and Forest Entomology 17(3): 270-276

Beth Ferguson *is currently a postdoc in Cesar Rodriguez-Saona's lab at Rutgers. My research experience is in Integrated Pest and Pollinator Management. Her current focus is in blueberries where she is working to improve pollination by understanding how timing of bloom, weather, and health of bees impacts fruit production.*

Top Takeaways about Berries from the Last 30 Years

Kathy Demchak
Dept. of Plant Science | Penn State University
102 Tyson Bldg. | University Park, PA 16802
efz@psu.edu

Berry crops are high value, and if you enjoy challenges, they just might be the crop for you! There is a lot that we can do though to make growing them a bit easier.

The Last 30 Years in a Few Paragraphs – or How Did We Get to Here?

Strawberries. When I started in this position, strawberries in Pennsylvania were essentially all in matted row production – a system that except for chemicals used and varieties grown, hasn't changed much over the last 500 years. The varieties grown in the northeastern and Mid-Atlantic U.S. for matted-row production were bred and evaluated here (and elsewhere), and the plants were grown at nurseries located in the eastern half of the U.S. But, matted-row production requires a full year of care before the first berries are harvested, weed control became a big challenge especially once fumigation became less widely-used, and berries of most varieties until recently were fairly small, a serious disadvantage for harvest and sale. Enter outdoor plasticulture, where you could wait until the end of the summer to plant, and get high yields of large berries the following spring before matted-row berries began to ripen. What wasn't there to like? Concerns at the time were that we were transplanting a system and varieties developed for it from a region that receives 15 inches of rain and 300 days of sun per year – but still with cool temperature – to the cloudy, warm, humid East. Because of this, we've some significant disease concerns in plasticulture production, and there will be no shortage of work to do for the foreseeable future in this system and perhaps beyond.

Hope is on the horizon though, and while spotted wing drosophila is here to stay, at least one recently arrived beneficial wasp that attacks it quite successfully is here to stay also.

Brambles. Raspberry and black production systems haven't changed a lot, but we have many more primocane-fruiting varieties available than we used to have. The arrival of spotted wing drosophila in 2011-12 completely changed the picture for bramble production. Hope is on the horizon though, and while spotted wing drosophila is here to stay, at least one recently arrived beneficial wasp that attacks it quite successfully is here to stay also.

Blueberries. Blueberry production is relatively new – just a little over 100 years old. The

***Kathy Demchak** has been at Penn State since 1983, working in berry crop research and extension since 1992. Prior to working with berry crops, she worked with vegetable and tree fruit nutrition and on strip-mine reclamation, all of which provided valuable experiences and many opportunities to learn. Her favorite part of her job has been getting to know the berry growers and her co-workers. She earned a B.S. in Horticulture from Penn State and an M.S. in Horticulture from Virginia Tech.*

Top Takeaways about Berries from the Last 30 Years (continued from page 96)

blueberry plant is adapted to soils with a low pH and high organic matter content. Just 30 years ago, nearly all of the production was in soils that naturally had these conditions, including in Pennsylvania where most of the blueberry plantings were located across the northern tier. Once the health benefits of blueberries started receiving more attention, consumer demand grew, and growers with all types of soils were tempted to try their hand at growing this crop, some successfully, and some less-so.

Top Take-Aways – and Points to Keep in Mind for Successful Plantings

It helps to know what is normal. Looking closely at plants that are healthy, and possibly dissecting them a bit to see what they look like inside, can be helpful when trying to figure out whether you really have a problem or not.

If the problem truly is a disease organism, you will normally see a relatively gradual change in color of some sort with no pattern on the plant. This happens as the plant tissue is being invaded, though you may need a magnifying glass to see it, and the color change is easier to find on plant tissue that is in decline and not completely dead yet. Color changes can be red margins around leaf or cane spots, perhaps with darker tissue in the center, a gradation from brown to olive to green at the tips of blueberry canes, tan wedges or concentric circles in blueberry canes cut crosswise, or brown or reddish-brown coloration in strawberry crowns. Phytotoxicity, or environmental causes, generally cause tissue to change from green to brown very quickly, and nutritional or herbicide issues follow some sort of pattern that is similar between plants.

It's hard to outsmart a fungus, and that goes for bacteria, too. Bacteria and fungi can make more (like many, many thousands) of themselves in a matter of minutes, hours, or a few days. What we see through microscopes is impressive, and sometimes a little shocking. Their ability to multiply also explains why resistance

development to fungicides and antibiotics (in the plant world and beyond) is becoming such an issue. Our use of, and dependency on, single-site fungicides is a relatively new phenomenon whereas older (and often more toxic) fungicides affected more processes.

If spraying isn't making symptoms improve, it's best to stop, take a step back, and consider other possibilities. This past year, growers were very concerned about our new strawberry disease, Neopestalotiopsis, and understandably so. But some of the growers spraying for it didn't have it and reported seeing spots or brown edges on new leaves just as they were growing out. This is more typical of salt injury or phytotoxicity, so once they took a break from spraying, the symptoms improved. Some diseases, like powdery mildew, require different fungicides than those used for other diseases, so spraying more with the wrong fungicide won't help and might hurt.

Continued on next page

Top Takeaways about Berries from the Last 30 Years (continued from page 97)

Except for in a research, lab, or closely controlled nursery setting, "clean plants" and "disease-free plants" are misnomers. Fields aren't operating rooms, and diseases have a way of getting around. Once a plant is growing, whether it's in the field or in a greenhouse, it's going to get exposed to something, and once it is in your field, it will be exposed to more. We're finding out more and more that plants that show no symptoms of disease organisms have potentially pathogenic fungi co-habitating with them, and both survive with the arrangement. One of our bigger surprises while doing research on black root rot was finding that strawberry plants that had low levels of Rhizoctonia (key words being "low levels") grew better than ones without any, and it took something else going wrong for the plants to "come down with the bug". This is why black root rot is often referred to as a disease complex – a combination of factors need to exist for the disease to develop.

On the positive side, most plant growth problems aren't caused by fungi or bacteria. Usually it's a matter of too much or too little water, the wrong pH, fertility, not pruning, or some combination of the above. When the plants aren't growing well, especially in the case of raspberries and blueberries, new growth isn't produced to replace the old growth, and whatever disease organisms or insects are out there accumulate, making the problem look even worse.

Roots "breathe", and they need oxygen just like we do. Roots don't photosynthesize, and except for some species in wetlands, plants can't move the oxygen that the leaves make to the roots. So roots are dependent on the oxygen they get from spaces in the soil. Without oxygen, they die. This is why it is so important to maintain a loose soil structure and it is also one of the reasons why larger strawberry production acreages are on sandier soils – whether in matted-row or plasticulture production. Many farms have heavy soils to start with, and once you add compaction to the mix, the plants struggle. The worst problems I've seen with black root rot on strawberries were in heavy compacted soils. Blueberries, with their fine "hair-roots", have grown much better when there was a lot of organic matter to loosen the soil. Brambles will survive almost anywhere, but still grow taller and produce higher yields on looser soils.

Long rotations really help, if you possibly can manage them. Growers often remark that there is nothing like new ground for a strawberry field. Of course, not everyone can find new ground, but the closer you can get to that, the better off the planting will be. Growers who have pick-your-own fields or limited ground often take the planting in the opposite direction, where they shorten up the time between strawberry crops just a little bit, but these plantings seem to go into a downward spiral over time.

There's no substitute for healthy, vigorous planting stock. Growers often mention that our yields in trials are higher than what they can get, and we largely attribute that to small plot trials and multiplying the area out to a larger acreage - which is definitely part of it. But it also finally dawned on me that I'd normally order 20% more plants than I needed and avoid using the weak plants as much as possible because of those small plots – we just couldn't risk losing many plants. That might sound extravagant to some growers, but it nearly always resulted in perfect or near-perfect plant stands.

The bottom line is that plants that start out small stay small for a long time, and if they arrive badly diseased, the diseases tend to stick around longer than the plants do. It costs just as much to establish a weak planting as a healthy one, and probably more. So when you purchase your plants, order some extra – you will likely will make that cost up in higher yields.

Effects of Sunn Hemp on Soil Fertility, Soil Health, and Organic Strawberry Production

Jianyu Li
University of Massachusetts

A two-season study (2017–2018 and 2018–2019) was conducted to evaluate the impact of sunn hemp (*Crotalaria juncea*) on soil fertility, soil health, and organic strawberry production. Sunn hemp seeds were inoculated with OMRI-listed Guard-N® seed inoculant (7.5 g/kg of seed) before sowing and broadcast-seeded at a rate of 40 lbs/acre on July 19, 2017, and July 24, 2018. The crop was grown without irrigation or fertilization. At the end of each season, the biomass was terminated, chopped into ≈5-cm pieces, and incorporated into the soil at a depth of 10 cm on September 21, 2017, and September 26, 2018. Sunn hemp produced an average biomass of 6,072 lbs/acre in 2017 and 4,599 lbs/acre in 2018, with nitrogen accumulation in biomass averaging 140 lbs/acre in 2017 and 110 lbs/acre in 2018. Approximately 62% of the nitrogen was contained in the leaf fraction.

***Dr. Jianyu Li** is an Extension Assistant Professor at the Stockbridge School of Agriculture, University of Massachusetts Amherst. With a commitment to sustainable small fruit and vegetable production, Dr. Jianyu Li's research primarily addresses nutrient management, advanced horticultural practices, and postharvest fruit quality. Additionally, they explore controlled environment agriculture techniques to extend growing seasons and enhance crop resilience in Massachusetts. Through the work, Dr. Jianyu Li aims to support sustainable practices that benefit both growers and consumers while reducing environmental impact.*

The study assessed soil health in three key areas: nitrogen (N) availability, soil respiration, and microbial community composition.

Key Findings

1. **Nitrogen Availability and Strawberry Production**

Incorporating sunn hemp residues into an organic strawberry production system led to a rapid increase in soil nitrogen availability within the first three weeks due to the fast decomposition of the biomass. However, this nitrogen release did not align perfectly with the strawberries' nitrogen requirements during the establishment phase, increasing the potential for nitrogen loss through leaching if heavy rainfall occurred. In the 2017 trial, sunn hemp plots exhibited significantly higher marketable fruit weight (59%) and total fruit weight (52%) compared to weedy fallow plots. Marketable fruit numbers per plant increased by 46%, with a trend of a 36% increase in total fruit numbers. Based on these findings, the waiting period between sunn hemp incorporation and strawberry transplanting was reduced from 22 days in 2017 to 8 days in 2018.

In the 2018 trial, sunn hemp continued to positively affect early-season strawberry yields. Total fruit number increased by 15%, total fruit weight by 14%, and marketable fruit number by 13% compared to the weedy fallow control. Marketable fruit weight also tended to be higher in sunn hemp plots. Shortening the waiting period between residue incorporation and strawberry transplanting allowed the strawberries to better utilize the nitrogen released during the early decomposition phase.

Continued on next page

Effects of Sunn Hemp on Soil Fertility, Soil Health, and Organic Strawberry Production (continued from page 99)

2. Soil Respiration

Soil respiration is a critical indicator of soil health because it reflects the biological activity and metabolic processes occurring within the soil ecosystem. It is the process by which soil organisms, including microbes, fungi, and plant roots, break down organic matter and release carbon dioxide (CO_2). Monitoring soil respiration provides valuable insights into soil fertility, organic matter dynamics, and overall ecosystem functionality. Sunn hemp residues significantly influenced soil respiration rates throughout the growing season. Soil respiration was 84% higher in sunn hemp plots compared to weedy fallow plots at 35 days after transplanting (DAT), 19% higher at 63 DAT, and 31% higher at 97 DAT. This increase was attributed to the rapid decomposition and mineralization of sunn hemp residues, which contributed to the active soil organic matter pool. By the late season (126 DAT and 155 DAT), no significant differences in soil respiration were observed, reflecting the exhaustion of labile biomass components and the persistence of recalcitrant materials such as lignin.

3. Microbial Community Composition

Soil bacterial community composition is a vital indicator of soil health because it reflects the diversity, functionality, and resilience of the microbial ecosystem, which drives essential soil processes. Bacteria play a critical role in nutrient cycling, including nitrogen fixation, organic matter decomposition, and the transformation of nutrients into forms accessible to plants. A diverse bacterial community ensures functional redundancy, meaning multiple organisms can perform similar roles, enhancing the soil's ability to adapt to environmental changes and stressors. Specific bacterial groups, such as nitrifiers (e.g., *Nitrosomonadales*), are closely linked to soil nitrogen availability and fertility, while others contribute to the breakdown of organic pollutants or suppression of soilborne pathogens. Changes in bacterial composition can signal shifts in soil conditions, such as pH, moisture, or nutrient status, offering insights into the impact of management practices or environmental disturbances. Thus, monitoring bacterial communities provides a comprehensive understanding of soil ecosystem health, productivity, and sustainability. Sunn hemp residues had a pronounced impact on the strawberry rhizosphere's bacterial community composition. The early-season abundance of *Nitrosomonadales*, a group of bacteria critical for nitrification, was significantly higher in sunn hemp plots. These fast-growing microbes (r-strategists) respond rapidly to the availability of decomposable organic substrates, highlighting their role in nitrogen release from sunn hemp residues. This alteration of the microbial community demonstrates how sunn hemp incorporation influences soil health through both nutrient dynamics and microbial activity.

Overall, the study highlights the potential of sunn hemp as a valuable soil amendment for organic systems, particularly for enhancing nitrogen availability and improving early-season strawberry yields. Properly timing the incorporation of sunn hemp residues relative to crop establishment is essential to optimize benefits and minimize nitrogen losses.

No-Till Vegetable Production

Sjoerd Duiker
Penn State University

Tillage has many drawbacks for farm economics and efficiency as well as for the environment and soil health. Tillage takes time, fuel and tractor power, and increases soil erosion, reduces water infiltration, reduces surface soil organic matter content, negatively affects soil structure, and reduces soil biological activity. Therefore, no-till systems were developed. No-till systems consist of three pillars: no-tillage, permanent organic cover on the soil, and diversity in the crop rotations. Due to its advantages, no-till has become very popular among Pennsylvania's field and forage crop producers – the latest statistics show that at least 67% of planted acres are now planted using no-till practices in Pennsylvania. However, no-till is uncommon among vegetable producers. In this presentation we will review possible reasons why no-till vegetable production is rare. Some possible reasons that will be reviewed are: (1) No-till equipment is not readily available for vegetables; (2) Soils are 'addicted to tillage' and when vegetables are planted without tillage in degraded soil they are stunted; (3) No-till soil is cooler than tilled soil due to insulation by crop residue and this causes slow early growth and delayed harvest of vegetables putting vegetable growers at a marketing disadvantage; (4) Mineralization of organic matter is slow resulting in nitrogen deficiency in vegetables; (5) Mechanical weed control is difficult in no-till causing challenges with weed competition. We will review these challenges and see if there are answers to help Mid-Atlantic farmers be successful with no-till vegetables. We will review no-till seeding and transplanting equipment options and how farmers can access them. We will see that current plastic bed culture discourages no-till adoption. We will evaluate if the management history of soils can make a difference in determining if no-till vegetables will be successful. We will determine if use of row cleaners, soil covers or high tunnels might help alleviate the cold soil syndrome. We will determine if use of certain cover crops, manure, or changes in fertigation practices can help alleviate reduced nitrogen mineralization from organic matter. And we will evaluate strategies and methods to manage weeds in no-till vegetables, among others by depleting the weed seed bank prior to starting with no-till vegetables, employing a zero-tolerance strategy for weed seed production, herbicide options, using cover crops and mulch for weed control, and using landscape fabric to reduce weed competition. We will illustrate the discussion with real life examples on Penn State's Horticultural Research Farm and vegetable farmers who have successfully adopted no-tillage.

***Sjoerd Duiker** is Soil Management Specialist in Penn State Extension's Agronomy Team. His program circles around farming practices that improve soil health.*

Due to its advantages, no-till has become very popular among Pennsylvania's field and forage crop producers – the latest statistics show that at least 67% of planted acres are now planted using no-till practices in Pennsylvania.

Healthier Food with No-Till Practices

Sjoerd W. Duiker [1], Wade P. Heller [2], Joseph E. Carrara [2], and Robert B. Beelman[3]

There is increasing interest among the medical community in the compound ergothioneine. Ergothioneine is an amino acid that is only known to be produced by fungi and some bacteria. It was discovered in the early 1900s in the ergot fungus, hence its name. However, ergothioneine is not dangerous to human health (unlike the ergot fungus). It is actually considered to be a longevity vitamin with benefits to human health because it is a powerful antioxidant that can neutralize radicals that cause cell damage. In addition, ergothioneine accumulates in tissues to protect them from being damaged. Interestingly, ergothioneine was found to be concentrated at high levels in brain tissues of mice with high propensity to attract Alzheimer's disease, probably to help reduce its onset. Therefore, regular consumption of ergothioneine is thought to reduce the risk of diseases of old age, such as Alzheimer's, Parkinson's, and cancers. The interest in ergothioneine surged after the discovery in 2005 of a specific transporter in animal and human cells that takes ergothioneine and transports it across membranes into the cell. The transporter is now referred to as ETT –ergothioneine transporter - and its presence suggests Ergothioneine is needed or at least highly beneficial to human health. Ergothioneine content is high in mushrooms and their regular consumption is therefore associated with lower risk of diseases of old age. However, ergothioneine is also found at low levels in plants and animals. Because our consumption of mushrooms is low, there is interest in evaluating ergothioneine content in other human foods, and how it could possibly be increased. An example of levels of ergothioneine content in different foods reported in the literature is given in Table 1.

Sjoerd Duiker *is Soil Management Specialist in Penn State Extension's Agronomy Team. His program circles around farming practices that improve soil health.*

A question that has been raised is: how does ergothioneine end up in plants and animals? Animals probably acquire ergothioneine from plants they eat, but how does it end up in the plants? Because ergothioneine is not known to be produced by plants themselves, the most logical source would be the soil. We hypothesized that the major origin of ergothioneine in plants would be arbuscular mycorrhizae that live in symbiotic relationship with plant roots of many (though not all) plant species. A collaboration between Penn State Departments of Plant and Food Sciences and USDA-ARS Eastern Regional Research Center allowed us to test this and indeed, we found that ergothioneine content was much higher in crops grown in sterilized soil that was inoculated with mycorrhizae than in uninoculated sterilized soil. We found that there was variation in the effectiveness of different strains of mycorrhizae at enhancing ergothioneine concentrations of plants, probably because of their success in colonizing plant roots. Ergothioneine content was 70-fold higher in mycorrhizal vs non-mycorrhizal black beans, and it was doubled by inoculating wheat and oats grown in field soil (Carrara et al., 2023).

Inoculation of plants with mycorrhizae is one way to increase colonization of the roots, but

[1] Dept. of Plant Science, Penn State University
[2] USDA Agricultural Research Service, Eastern Regional Research Center, Wyndmoor, PA
[3] Dept. of Food Science, Penn State University

Healthier Food with No-Till Practices (continued from page 102)

Table 1. Ergothioneine content in different foods (Adapted from Halliwell et al., 2018)

Food	Ergothioneine (mg kg-1 dry weight)
Oyster mushroom	542
Tempeh	201
Garlic	34
Thai asparagus	10
Soybean curd	4
Brazil nut	4
Oats	2
Almond	2
Onion	1
Broccoli	<1
Kale	<1

we know from other research that management practices also play a pivotal role in mycorrhizal colonization of crop roots. One practice that is known to have a significant effect on mycorrhizae is soil tillage. Tillage breaks up the mycorrhizal hyphae and that probably sets them back so that they are less successful in colonizing plant roots. To test the relationship between tillage and ergothioneine content, we analyzed grain from a long-term tillage study at Penn State (Beelman et al., 2021). Three types of tillage are represented in this trial, namely moldboard plowing/disk harrowing/cultipacking, chisel plowing/disk harrowing/cultipacking, and no-tillage. These treatments have been in place since 1978. The crops tested were corn, soybeans, wheat and oats. These crops are grown in rotation in this trial in a corn-soybean-small grain/legume cover crop rotation (small grain is usually wheat but replaced with oats in case of excessive moisture in fall). In our research we found 30% lower ergothioneine content in moldboard plow than in no-till in corn, soybean and oats. In wheat, we measured only half the content of ergothioneine as in no-till and this was associated with a reduction in mycorrhizal colonization of the wheat roots. Therefore, our research confirmed that ergothioneine content can be expected to be higher in crops grown with no-tillage or very minimal tillage due to its effect on mycorrhizae. This research is the first to show a relationship between improved soil health and nutritional quality of the food produced as a result of reduced tillage intensity.

References

Beelman, R.B., J.P. Richie, Jr., A.T. Phillips, M.D. Kalaras, D. Sun and S.W. Duiker, 2021. Soil disturbance impact on crop ergothioneine content connects soil and human health. Agronomy 2021, 11, 2278. https://doi.org/10.3390/agronomy11112278

Halliwell, B., I.K. Cheah, and R.M.Y. Tang. 2018. Ergothioneine – a diet-derived antioxidant with therapeutic potential. FEBS Letters 592:3357-3366. doi 10.1002/1873-3468.13123

Restoring Your Soil Health with Anaerobic Soil Disinfestation

Francesco Di Gioia
Department of Plant Science
Pennsylvania State University

Soil health has been defined as "the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health". Preserving and promoting soil health is critical for the long-term viability and sustainability of agroecosystems. Monoculture and intensive cultivation of our soil year after year can lead to a rapid decline of soil health and to the emergence of a series of soilborne pest and pathogen issues which can negatively impact plant health and crop productivity. Within the Mid-Atlantic region, especially in high tunnels, emerging soilborne pests and pathogen issues include plant parasitic root-knot nematodes (Figure 1), lesion and dagger nematodes, fungal pathogens such as Fusarium wilt (*Fusarium oxysporum*), Fusarium crown and root rot (*Fusarium oxysporum f.sp. radicis-lycopersici*), Corky root rot (*Pyrenochaeta lycopersici*), Verticillium wilt (*Verticillium dahliae*), and Southern blight (*Athelia rolfsii*) (Figure 2), along with weeds.

Fig. 1. Example of tomato root system severely affected by root-knot nematodes.

Francesco Di Gioia *is an Associate Professor of Vegetable Crop Science in the Department of Plant Science at The Pennsylvania State University. With 50% research and 50% extension appointment, his integrated research and extension program focuses on improving the sustainability of vegetable crops and their nutritional quality across different systems (open field, protected, and controlled environment, in soil, and soilless systems). He received his B.S. and M.S. in Agricultural Science and Technology and his Ph.D. in Mediterranean Agronomy at the University of Bari in Italy. Before joining Penn State in 2018, he was a postdoc at the University of Bari and the University of Florida.*

Although crop rotations and the use of cover crops are highly recommended as a preventing strategy, the emergence of soilborne pests and pathogens requires the implementation of curative solutions capable of reestablishing soil health. Among the alternative soil disinfestation approaches available, Anaerobic Soil Disinfestation (ASD) is increasingly proposed as a biological solution capable of suppressing a wide range of soilborne pests and pathogens while also resetting and promoting soil health. ASD is applied in pre-planting by 1) incorporating in the soil easily decomposable organic amendments; 2) tarping the soil with an impermeable polyethylene film; and 3) irrigating the soil to saturation.

Amending the soil with a source of easily decomposable carbon (sugars) stimulates a rapid growth of the soil microbial population, leading to the rapid exhaustion of oxygen in the soil and

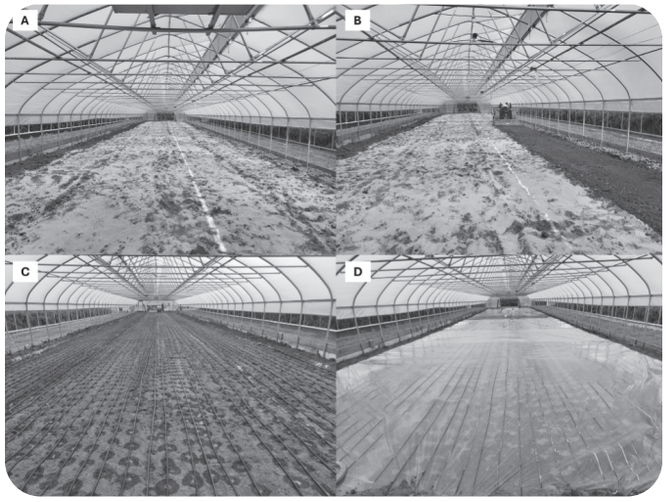
Restoring Your Soil Health with Anaerobic Soil Disinfestation (continued from page 104)

Fig. 2. Example of tomato plant affected by Southern blight.

to the development of anaerobic conditions. The use of an impermeable film (possibly totally impermeable film) and the soil saturation with water determine the rapid development of anaerobic conditions, which may last for one to three weeks. With the development of anaerobic conditions, the organic amendment applied to the soil is fermented generating organic acids and volatile organic compounds which can suppress soilborne fungal and bacterial pathogens, plant-parasitic nematodes, and weeds. After the initial rapid decomposition of the labile fraction of the organic amendment, the soil gradually returns to aerobic conditions and within 3-4 weeks a new crop can be planted.

Among other factors (soil type, temperature, moisture), the organic amendment (carbon source) type and application rate used to initiate the ASD treatment plays a critical role in determining the efficacy of suppression of soilborne pests and pathogens and influence the microbial activity and the availability of nutrients in the soil during and post-ASD, thereby affecting soil health and crop performance. A revolutionary aspect of this soil disinfestation method is the opportunity to selectively suppress soilborne

Fig. 3. Example of on-farm Anaerobic Soil Disinfestation application using wheat middlings and feed-grade molasses as carbon source, and clear or black totally impermeable film as a tarp. Wheat middlings are spread on the surface of the soil (A), incorporated within the root zone with a rototiller (B), molasses is applied via fertigation while irrigating the soil to saturation with drip tapes placed every 10-inches (C), meanwhile, the soil surface is tarped with an impermeable film, making sure to seal the film all around its edges (D). Three to four weeks later, the tarp is removed and once the soil is aerated a new crop can be established.



pests and pathogens while promoting the growth of beneficial microorganisms, with long-term effects on soil health.

Acknowledgements

This research has been funded by the USDA, NIFA, Organic Research and Extension Initiative program (Grant #2021-51300-34914), the USDA-NIFA Organic Transitions program (Grant #2024-51106-43166), the USDA NIFA Crop Protection and Pest Management program (Grant #2021-70006-3531), and the USDA Agricultural Research Service Areawide Project on Anaerobic Soil Disinfestation (Pennsylvania State University Agreement #58-6034-8-018).

Corn Earworm Management Strategies

Kelly A. Hamby
University of Maryland
4112 Plant Sciences Building | College Park, MD 20742
kahamby@umd.edu

Work to improve corn earworm management.

Corn earworm management has become more difficult, more expensive, and less effective. Partnering with producers, crop consultants, and other stakeholders, we have formed a regional team to develop and deliver resources for corn earworm management, including a new website where project updates will be posted: https://www.cewipm.org/.

Economics survey. Our short survey will help us understand the current practices used by growers for CEW control, and the costs associated with different practices. It is aimed specifically at fresh-market growers, and not at growers of sweet corn for processing (another survey will be used to obtain information on those farms). We will use the information to identify current fresh-market CEW control practices and their costs, and to evaluate how alternative CEW control practices affect grower costs, sales, and financial performance. Our findings will directly help growers assess the value of alternative control practices to their own businesses.

We offer an online version of this survey and a 2-page paper version, so growers can choose the method that works best for them. Our analyses will aggregate data for different types of growers distinguished by size, region, and marketing outlet. For that reason the questionnaire opens with a set of questions concerning the type of sweet corn enterprise, before asking about specific management practices used to control CEW. We will report estimates for different grower types; all individual responses will be kept strictly confidential, and the questionnaire elicits no personal information about any individual grower.

***Dr. Kelly Hamby** is an Associate 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, in small fruit, sweet corn, 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.*

Current best practices.

Bt hybrids. Performance, Attribute, Attribute II, and Attribute Plus Series sweet corn hybrids express insecticidal proteins from *Bacillus thuringiensis* (Bt) bacteria that protect against caterpillar pests. In combination, the Vip3A and Cry1Ab proteins expressed by Attribute II and Attribute Plus series hybrids provide near 100% control of caterpillar pests of sweet corn, especially whorl and ear invading caterpillars such as European corn borer (*Ostrinia nubilalis*), fall armyworm (*Spodoptera frugiperda*), and corn earworm (*Helicoverpa zea*). Performance series (Cry1A.105+Cry2Ab2 protein) and Attribute I (Cry1Ab protein) continue provide 100% protection against European corn borers (*Ostrinia nubilalis*) in the Mid-Atlantic throughout the

Corn Earworm Management Strategies (continued from page 106)

season (whorl, tassels, and silks). However, fall armyworm and corn earworm have developed resistance to these products which will require silk sprays to achieve fresh market quality.

Silk spray programs. Initiate silk spray programs when the very first silks appear and determine spray schedules based upon corn earworm trap captures, geographical location, time of the year, preharvest intervals, and market. Depending upon the region and the type of trap used, <1 corn earworm moth per pheromone trap per night would be considered low enough pressure to skip sprays or use longer 5-6 day schedules. Corn earworm captures of more than 10 moths per pheromone trap per night indicates heavy enough pressure that 2-3 days schedules would be appropriate. Traps on farm provide the best precision for timing silk sprays. Weather fronts can bring in migratory moths very quickly so it is also important to keep an eye on regional captures and weather patterns. Warm temperatures (>80°F) increase the growing speed of silks (unprotected tissue emerges) and corn earworm (move down the silks faster), so tighter spray intervals may be necessary. Rainfall and overhead irrigation also wash away insecticide residues so reapplication when the silks have dried may be necessary.

Corn earworm populations can be resistant to pyrethroid insecticides [Insecticide Resistance Action Committee (IRAC) group 3A], so this group should be rotated with other groups and used with caution. Products containing group 5 (examples: Blackhawk, Radiant), 5+18 (example: Intrepid Edge), 28 (examples: Coragen, Vantacor), and 28+3A (examples: Besiege, Elevest) insecticides generally work well for corn earworm. The most effective OMRI approved insecticide for corn earworm management is Entrust (group 5). Good coverage of the silks is required for effective control.

EPA Pesticide Use Updates Affecting Vegetable Production

Megan Luke
Penn State Extension
Lake Erie Regional Grape Program
MFL5873@psu.edu

The EPA has released its final decision regarding herbicide use mitigation measures and changes to the re-registration and labeling process. In addition, the EPA has recently released a similar report for ALL insecticide registrations and registration reviews that are similar in scope and execution to the herbicide strategy. Several significant changes to pesticide labels are being rolled out beginning in late 2024. Specifically, there is a new requirement to check their Bulletins Live! 2 website before all herbicide and insecticide applications (when required by the label) and the requirement to include documented mitigation strategies when applying herbicides to reduce runoff and drift and/or if the farm operation is within a Pesticide Use Limitation Area (PULA), i.e., critical habitat for one or more endangered species.

These label changes are already going into effect: as pesticides come up for review and re-registration, they will be applied to the updated label. Growers can expect to see these requirements becoming more common each growing season, and they need to become accustomed to looking for the requirements and checking online sources as indicated.

A toolbox with information, webinars, guides, and calculators for meeting these new pesticide use requirements has been developed and released. Remember: these changes are occurring on a federal level, and ALL growers are subject to these new use requirements.

The toolbox can be found here: https://www.epa.gov/endangered-species/pesticides-and-endangered-species-educational-resources-toolbox

These changes to pesticide use requirements require additional record-keeping and research before every pesticide application.

Key takeaways:

- Checking the Bulletins Live! website is mandatory if listed on the pesticide label
- The EPA is working with the U.S. Fish and Wildlife Service to create maps of every endangered and protected species in the USA and their critical habitat.

EPA Pesticide Use Updates Affecting Vegetable Production (continued from page 108)

  - Currently, 8 total regions in the USA are designated as Pesticide Use Limitation Areas (PULAs), and this number and the ranges of these designated areas are subject to change.
- Every new herbicide and every herbicide due for re-registration will have a mitigation requirement added to the label
  - Herbicides and insecticides deemed higher risk may require more mitigation tactics to be in place at the time of use
  - Farmers MUST demonstrate commensurate mitigation practices to the requirement on the label and/or the Bulletins Live! website (if located within a PULA) to USE THE HERBICIDE
- All current information on PULAs and required mitigation practices over and above those on the print label will be hosted EXCLUSIVELY on the website
- If your farming operation is within a PULA, you will be required to demonstrate compliance with mitigation measures as defined by the EPA
  - Mitigation measures are outlined in a special bulletin on the EPA's Bulletins Live! website and are required by law as an addendum to the pesticide label
  - Measures will include practices such as cover cropping, conservation tillage, drift reduction practices, contour farming, etc.
  - New buffer zone requirements will be implemented specific to PULA and the associated risk of the product in use
  - In some cases, specific measures MUST be employed and clearly described. In other cases, a farmer may demonstrate compliance by utilizing various methods specific to their operation AND recognized by the EPA as impactful.
- Methods of enforcing these measures have not been widely discussed, and at this time, compliance will be checked as part of routine state government agency inspections.

Full Herbicide strategy can be found here*: https://www.regulations.gov/docket/EPA-HQ-OPP-2023-0365

Full Insecticide strategy can be found here*: https://www.regulations.gov/docket/EPA-HQ-OPP-2024-0299

EPA's Bulletin Live! 2 website can be found here: https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins

EPA's Mitigation Menu website can be found here: https://www.epa.gov/pesticides/mitigation-menu

Maximizing Foliar Nutrition and Update on Silicon

Steve Bogash
Steve Bogash Consulting

Applying foliar nutrients to supplement soil applied nutrients has become common practice for many growers. Being sure that these treatments are effective and safe for plants is very important as phytotoxic reactions or an apparent lack of efficacy are commonplace among growers. We'll discuss what we know about foliar applications and how to make them safer and more effective.

The movement of nutrients into leaves from a foliar application is a passive process so is very distinct from how plants pull nutrients in through their roots which is an active process that is driven through evapotranspiration. There are two primary variables that determine how effective an application will be: 1) the nutrient concentration gradient between the leaf surface and that of the leaf interior. and 2) Leaf surface permeability.

If the concentration of nutrients is high in the epidermal cells, then few nutrients will move across the barrier as the cuticle and epidermal leaf structure helps to protect plants and has little permeability. Only through tissue testing and / or sap testing can growers determine what their plants need. If nutrients cannot move across the barrier, then they will accumulate on plant surfaces which can increase the chances of phytotoxic reactions. This explains why we often use very low concentrations of nutrients in application equipment.

Most foliar application suggestions include 'Spray to completely wet, but not to the point of runoff'. This is to keep from increasing concentrations on lower leaves and leaf tips from accumulated nutrient salts. It's not unusual to see leaf margins with scorch from accumulated nutrients. In outdoor conditions, rainwater will generally keep nutrient salts from building on leaves, but indoors this can be more challenging to avoid. If making regular applications of nutrient solutions to high tunnel or greenhouse grown plants, it may pay to periodically 'wash' the leaves with clear spray water when the humidity is low and the plants will experience good drying conditions after the wash so as to avoid creating conditions where diseases can thrive.

***Steve Bogash** retired from PSU Cooperative Extension in June 2016 and from ProFarm Group formerly known as Marrone Bio Innovations August 2024. Steve now consults for ProFarm Group, growers, and other bio-focused or plant nutrient focused companies. One of the most exciting things about this stage of his life and his career is helping to usher in this next wave of safe, effective, biological pest management products. With a 90+ year old, brick home there is always the next project. Steve is also burnishing his woodworking skills in semi-retirement as he learns to build small boats.*

There are two likely pathways for nutrients to move into leaves: 1) through aqueous cuticular pores, and 2) through stomata. We'll discuss these pathways in depth as particle size, chemistry, and leaf wetness / relative humidity all impact this flow.

In general, smaller particles such nano-particles and chelates have an easier time moving into leaves. As this flow is passive in nature, the combination of particle size, adjuvant, concentration, and relative humidity all impact successful foliar nutrient applications. Another class of particles are those attached to sugars. There is solid research supporting the use of sugar-bound nutrients as highly effective in moving into plant tissue through cuticular pores.

Maximizing Foliar Nutrition and Update on Silicon (continued from page 110)

The inclusion of foliar applications can have an additive and perhaps even synergistic impact on uptake of important nutrients. N, P, K, Ca, Fe, and Mg (Zn, B, & Mn when badly deficient). Foliar applications are rapidly available for incorporation into plant and fruit tissue and can make up for nutrient deficiencies or taking advantage of 'luxury' uptake. Tomatoes, peppers, cucumbers, & melons are all 'luxury' feeders of K. Greater K levels generally increase sugar levels and can keep tomatoes bearing higher quality fruit longer. High consumption (rapid fruit and plant growth) and low transpiration periods are ideal for using foliar applications for fruit improvement. This is especially important in the balance between Ca / Mg / K for BER, cracking, and yellow shoulders prevention. For high tunnel and greenhouse growers, the period in the spring when light levels are highly variable and often low for multiple days and sometimes weeks often results in BER due to poor movement of Ca and Mg from the roots. Twice weekly applications of Ca and Mg will reduce those early fruit losses.

Rules for Increasing the Efficacy of Foliar Nutrient Applications:

1) Leaf surfaces must be wet for nutrient movement. Once dry the nutrients just sit on the surface, but can rewet for later application. As nutrient levels increase, so does the chance for phytotoxic burns.
2) Smaller nutrient particles are better as they can more easily penetrate plant leaf pores.
3) Always wet leaf surfaces thoroughly, but not to the point of runoff.
4) Humidity matters a lot; if the leaves dry quickly then nutrients will not permeate leaf surfaces.
5) Adjuvants / surfactants can have a significant impact on the efficacy of an application. Reducing surface tension for better coverage often increases the movement into leaves.
6) Keep the concentration of any nutrient low as you cannot move a lot of nutrient foliarly. Follow the manufacturer's instructions carefully.
7) Test a few plants when using any new mix or product before committing the whole crop. Wait 2-3 days after a test application to evaluate the results.
8) Tomatoes do not come back from a phytotoxic burn quickly. Be careful!

Challenging Diseases on Tomatoes

Mary Hausbeck
Professor and Extension Specialist | Michigan State University
140 Plant Biology Lab | East Lansing, MI 48824
hausbec1@msu.edu

Bacterial Disease

Important diseases of tomatoes can result from infection by bacteria and most commonly include bacterial canker and bacterial spot. In recent years, bacterial disease has caused devastating losses to growers producing fruit either for the fresh market or for processing.

Bacterial spot affects the fruit and results in brown/black corky lesions that may be somewhat sunken. These spots cause the tomato fruit to be unmarketable. Even the fruit targeted for processing may become unusable because the spots prevent the skin from slipping off. Yield loss can occur if the foliage becomes heavily diseased and blighted. As portions of the foliage die from bacterial spot, sunscald of the fruit commonly occurs. Steps to prevent bacterial spot must start early in the season. This pathogen can be seedborne, so early leaf spotting may appear on seedlings while in the greenhouse. Bacteria spread from plant to plant via water such as splash droplets from overhead watering. Since bacteria prefer warm, wet environments, transplants growing in a greenhouse offer a perfect home for bacterial spot. Bacterial spots on transplants can mimic Alternaria leafspot, and certain growing stresses. Look for these common bacterial spot symptoms:

- Small, dark brown/black spots with a yellow halo
- Blotchy spots on the leaf and stems
- Spots with tan centers

***Mary Hausbeck** is a University Distinguished Professor and Extension Specialist at Michigan State University where she focuses on pathogen detection and disease management of vegetable crops and greenhouse flower and ornamental plants. She received her PhD in plant pathology at Penn State. Her research and extension program has supported and trained many students.*

Bacterial canker is diagnosed yearly and causes plant stunting, wilting and fruit spotting. Although yield losses vary among years, bacterial canker has the potential to be devastating. Young plants are more susceptible than older plants. Bacterial canker can be introduced into a clean field via transplants, machinery and wooden stakes or other equipment that has been previously used in an infested field. Once a greenhouse or field is contaminated with bacterial canker, steps must be taken to assure that future crops remain disease free. If a greenhouse is contaminated, remove all plant material from the greenhouse (including weeds and dead plant tissue on the floor), wash and

Since bacteria prefer warm, wet environments, transplants growing in a greenhouse offer a perfect home for bacterial spot.

Challenging Diseases on Tomatoes (continued from page 112)

disinfect floor surfaces, hoses, equipment, etc. with a 10% solution of bleach or a commercial disinfestant (GreenShield is an example). Wooden structures such as benches or trays should be soaked in a disinfestant such as bleach (10%) or GreenShield for a minimum of an hour and preferably overnight. A simple washing of wooden surfaces is inadequate because of the cracks and crevices that may allow the bacteria to escape a surface wash. Bacteria that overwinter on a wooden surface may be carried to the plants in water droplets next season during the splashing of overhead irrigation.

A contaminated field should be rotated out of tomatoes for at least three years. At one time it was believed that a rotation of at least five years was necessary, however, it is now known that the level of bacteria in a contaminated field drops dramatically after the first year of rotation. Copper sprays every five to seven days may help reduce the spread of bacterial canker. However, if the environment is favorable for bacterial canker (75-90°F with rain) coppers may be limited because the bacteria have a decided advantage in a wet environment. Avoid working in a diseased field when it is wet to avoid spreading the disease. Bacteria may enter the plant through natural openings, or wounds created by wind, pesticide spraying or insects. A film of water on the leaf surface allows the bacteria to remain viable and move. If workers are moving within a wet field and creating new wounds on the plants, new infections may occur.

At one time it was believed that a rotation of at least five years was necessary, however, it is now known that the level of bacteria in a contaminated field drops dramatically after the first year of rotation. Copper sprays every five to seven days may help reduce the spread of bacterial canker.

Fungal Leaf and Fruit Rots

Anthracnose is caused by the fungus *Colletotrichum coccodes* and causes a rotting of ripe fruit which reduces yield and fruit quality. Disease symptoms do not appear on the foliage. Early symptoms include slightly depressed, water-soaked circular spots that increase in size (up to 1/2”), become further sunken and may contain a pattern of concentric rings. As the fungus spreads within the fruit, a semi-soft decay occurs. Lesion development is most rapid at 80°F and disease development is greatest during wet, rainy weather. To control the disease, a 2-or 3-year crop rotation is suggested. Also, avoidance of sandy soil sites to minimize injury from blowing sand particles will reduce anthracnose.

Early Blight is caused by the fungus *Alternaria solani* and infects foliage and ripening fruit. Infection can occur at the point of attachment to the stem and through growth cracks and wounds on the fruit. The early blight fungus causes dark brown, leathery sunken spots with concentric rings. When young fruits become infected, they may drop off prematurely. Infection is greatest in warm weather (75-85°F). Heavy dews, extremely humid weather and abundant rainfall are essential for heavy disease pressure. To control the disease, a 3-or 4-year rotation will reduce the levels of the fungus in the soil.

Soil rot is caused by the fungus *Rhizoctonia solani* and causes slightly sunken brown spots about 1 inch in diameter on fruit that are in

Continued on next page

Challenging Diseases on Tomatoes (continued from page 113)

Late blight symptoms include blighting on all aboveground parts of the tomato plant. Lesions on leaves often appear dark and oily with production of sporangia occurring on the undersides of the leaves resulting in a whitish/purplish appearance especially when conditions are wet and humid. These sporangia can be carried long distances from diseased plants to nearby healthy plants via wind currents and storm fronts.

contact with the ground. Dark concentric markings are distinct within new spots and eventually the center of the spot may crack. Disease usually appears on ripe fruit in contact with soil. Disease is promoted by wet conditions. The pathogen is present in all field soil and affects tomato fruit whenever conditions are favorable.

Late blight is a disease that most commonly affects potatoes, but can affect tomatoes when the weather is cool, rainy, and humid. The pathogen is called *Phytophthora infestans* and is well known to potato growers. Late blight symptoms include blighting on all aboveground parts of the tomato plant. Lesions on leaves often appear dark and oily with production of sporangia occurring on the undersides of the leaves resulting in a whitish/purplish appearance especially when conditions are wet and humid. These sporangia can be carried long distances from diseased plants to nearby healthy plants via wind currents and storm fronts. Blackened lesions on the stems also occur and are typical of late blight disease. Late blight affects green and ripe tomato fruit. The blighting on the fruit appears as dark, greasy areas that enlarge rapidly, encompassing the entire fruit. During wet and humid conditions, white masses (sporangia and threads) of the late blight pathogen can be seen on the diseased leaves and fruit. Between cropping seasons, the fungus survives on volunteer and abandoned potatoes in cull piles. Control measures include eliminating all potato/tomato cull piles and destroying volunteer potato plants that grow from overwintered tubers. Infected potato plants established from diseased seed potatoes are another source of late blight. Most tomato varieties are susceptible to late blight. 'Mountain Magic' is a late blight resistant variety. There are several highly effective fungicide sprays that can be used to protect tomato plants from late blight. Homeowners and organic growers had limited tools available and may not always be able to hold the disease once it started. Conventional growers who use fungicides as part of their overall IPM program may find that many of the fungicides used for Alternaria, Septoria, and Anthracnose may provide some protection against late blight.

Growing Trellis Cucumbers in High Tunnels and Fields

Peter Flynn
Pete's Produce

Good morning everyone. Today, I'll share my experiences with growing trellis cucumbers in high tunnels and provide insights from Galen Hess, who grows over 20 acres in the field. I'll also share a video of a farm in Georgia to give you additional ideas.

Understanding Cucumber Types

Before we dive into the growing techniques, let's discuss the three main types of cucumbers:

1. Gynoecious

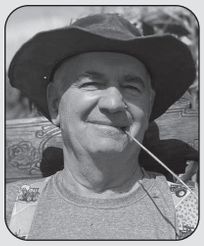
- These plants have only female flowers and require a pollinator plant with male flowers to ensure pollination. Often 15% of the seed will be the male pollinators.
- They are commonly used for field-grown cucumbers because their pollination needs align well with outdoor conditions.

Expect an 8 week harvest window.

2. Monoecious

- These have both male and female flowers on the same plant, making them more efficient to grow in the field as they don't require separate pollinator plants.

Expect a 12-week harvest window.



***Peter Flynn** is a retired vegetable farmer with a distinguished agricultural background. Upon earning a Bachelor of Science degree in agriculture from Michigan State University, he dedicated ten years to dairy farming before strategically transitioning to the cultivation of sweetcorn and vegetables. Notably, he established and managed a thriving retail market. With over 35 years of operational success, Mr. Flynn maintained a prominent farm market in Chester County. Currently, as a long-time member of the Pennsylvania Vegetable Growers Association, he contributes his expertise by serving on the board as president.*

3. Parthenocarpic

- These cucumbers do not require fertilization to produce fruit, making them ideal for high tunnels and greenhouses.
- They produce a high yield of cucumbers, but their thin skins result in a shorter shelf life. However, they are known for their tendernessand excellent flavor.

Expect a 12-week harvest window.

High Tunnel Cucumber Production

Planting Process

- We used parthenocarpic varieties, particularly 'Katrina,' which we found to perform best in high tunnels. Lisboa is a slightly larger variety that does well in the high tunnel.
- Seeds were started in 50-cell trays, 1 seed per cell, in early March, then transplanted into 4-inch pots once they developed true leaves.

Continued on next page

Growing Trellis Cucumbers in High Tunnels and Fields (continued from page 115)

- Transplants were planted in the high tunnel during the first week of April.

Frost Protection

- A heater was placed in the 30’ x 100’ high tunnel to protect the plants from late frosts.
- Two years in a row, we began harvesting cucumbers by the end of April when the plants were only about 2’-4’ feet tall.

Training and Trellising

Have demo clips and spools

- A trellis system was used to support the plants.
- Frequent maintenance is required:
- Attach plants to strings as they grew.
- Thin out clusters, allowing only one cucumber per cluster.
- Prevent cucumbers from getting stuck in clips or trellis rings.

Scout for insects and disease regularly

Fertilization and Nutrition

- Soil was regularly tested, and we applied fertilizer through drip irrigation weekly, adjusting for nutrient needs.
- As plants grew taller, we “dropped” and uncoiled the vines to continue harvesting without damaging the plants.

Spacing

- Plants were spaced 1 foot apart, with rows 4 feet apart to maximize the high tunnel’s valuable space.
- Always keep extra transplants on hand to replace any that fail early on.

Challenges

- The biggest pests in the high tunnel were spider mites, while cucumber beetles were surprisingly minimal.
- Consistent scouting is essential to control pests and maintain plant health.

Growing Trellis Cucumbers in High Tunnels and Fields (continued from page 116)

Play video from True food tv. “How does it grow, cucumbers” by Nicole Jolly

Field Cucumber Production

Planting and Transplanting

- Galen planted ‘Senora’, a reliable variety for field production. Python and a new variety SVCS2025 are two other monoecious varieties that do well
- Seeds were started in 98-cell trays, two seeds per cell, and hardened off quickly to prevent stretching.
- Transplants were planted when they were small, with spacing of 18 inches between plants and 5–6 feet between rows.

Trellising System

- Stakes were set 10 feet apart, using 2x2 stakes that were 6 feet tall and pounded 18” to 24” deep.
- High-tensile wire was stretched across the stakes, with 69-inch netting draped over the wire and attached for support.
- Netting height was limited to make harvesting more efficient in larger fields. Cucumbers are dumped into an elavtor over top of stakes.

Harvesting and Yield

- Field trellis cucumbers typically yield about 12 weeks of harvest, compared to 8 weeks for ground-planted cucumbers.
- Trellis cucumbers are preferred for their uniform appearance, lack of yellowing, and higher yield per acre.

Key Practices

- Avoid overwatering young plants to prevent stretching.
- Incorporate fertilizer at planting and maintain weekly fertigation schedules.
- Regularly tighten trellis systems to ensure support.

Industry Trends

The cucumber industry is shifting toward trellis systems, similar to how high-tunnel tomatoes gained popularity. Trellis-grown cucumbers offer:

- Higher yields.
- Better-quality fruit with a consistent, solid green appearance.
- Improved efficiency during harvesting.

This shift is driven by the benefits of walking through organized rows instead of stepping on vines and new growth in ground-planted systems.

Conclusion

By carefully managing trellis systems, plant nutrition, pest control, and spacing, both high tunnel and field-grown cucumbers can achieve excellent yields and quality. Whether you’re working with the controlled environment of a high tunnel or the broader scale of a field, trellis cucumbers represent the future of cucumber production. Thank you!

Agricultural Plastics; A Better Way to Recycle/Reuse and Be Sustainable

Dr. Mike Orzolek, Dr. Bill Lamont and Jim Garthe
The Pennsylvania State University
University Park, PA

Introduction

The largest use of polyethylene resin is in the production of plastic film mulch that is placed on top of the soil surface (mainly as raised beds) to increase soil temperature, maintain soil moisture and reduce/eliminate weeds in the bed by using different mulch colors and thickness. Today, million of pounds of plastic mulch are used extensively around the world including China and India that have to feed several billion people each day. In the last 10 years, film mulch thickness has decreased to the point that it will degrade more rapidly but micro and nano pieces of the degraded plastic mulch pollute both soil and water and reduce the sustainability of the soil over time.

While agricultural as well as consumer plastics offer many benefits to food production and consumer product marketing, the real on going problem for users of agricultural and consumer plastics is disposing of the plastic in environmentally safe and sustainable methods. Unfortunately, plastics are now a major pollution problem around the world in both soil and water.

Today, plastics are used in agriculture throughout the world for greenhouse coverings, mulches, row covers, cold frames, containers, irrigation components, etc in plant production. Agricultural plastics are also used in animal production for hay wraps, silage bags and silage covers. No other material has contributed more to increasing the productivity of agriculture than plastic. A variety of compositions of plastic films, types and structural designs help mitigate climate and weather while providing intensified expansion vertically and horizontally. Plastic technology

Fig. 1. Used plastic mulch and drip tape placed in a pile on the farm away from public viewing. Photo courtesy of Dr. Bill Lamont.

is especially appealing in China, Japan, the Netherlands, Israel, India and Egypt where population densities are high, land and water resources are constrained and climates are most favorable for its use.

Globally, plastic waste accounts for about 12% of municipal solid waste (MSW) by mass. In European countries, plastic waste accounts for 5.4% to 21%, while in China, it accounted for 11.3% to 17.2% of total MSW from 2002 to 2011. It is generally believed that poor solid waste management (either non-management or mismanagement) such as littering and dumping are the primary source of plastic waste into the environment.

Nurserymen, landscapers, truck farmers, mushroom growers, hothouse owners and even

Agricultural Plastics; A Better Way to Recycle/Reuse and Be Sustainable (continued from page 118)

dairy farmers produce varying amounts of plastic waste.Vegetable and animal producers have attempted to burn the plastic, bury the used plastic in a sinkhole, sending it to a landfill or building a pile of used plastic in the back 40 hidden from the public.

Burning and burying plastic film and extruded plastic products are illegal in most areas, and many landfills are filling up and closing down. What is the solution?

Recycle

There are four categories of plastic recycling: 1st - is the creation of a similar quality product from the recycled source, 2nd - the creation of products from the reclaimed material with less demanding specifications such as composite lumber, 3rd - the use of a recycled product as a chemical raw material and 4th - the incineration of a waste plastic to reclaim heat (waste) energy. Because all the plastics used in the agriculture sector are contaminated with soil, plant matter, chemical residues and air pollutant contaminates, without extensive cleaning, much of the used agricultural plastics end up in the landfill.

Roadblocks to recycling used agricultural plastics are not limited to contamination. Recyclers also prefer and/or require the recovered material to be sorted by plastic type. This sorting process can be difficult since film plastic could be polyethylene or polypropylene, while rigid plastics can be polystyrene, polyethylene or polypropylene. However, classification of plastics by type cannot be done by sight alone.

Energy Reclamation$_2$

Plastics, which include contaminated LDPE film, have a higher energy value and heat content than most municipal solid waste materials. While making up seven percent of the waste stream by weight and 20 percent by volume, plastics provide incinerators with 25 percent of the recoverable MSW (municipal solid wastes) energy. For example, a pound of polyethylene supplies 19,000 Btu, but corrugated paper packaging provides only 7,000 Btu (See Table 1 to compare the energy value of plastics to other municipal solid wastes and natural resources.) Three of the most commonly used plastics in the agricultural industry--polyethylene, polypropylene, and polystyrene--have energy values per pound that are equal to fuel oil and even greater than Wyoming coal. Because of their high Btu content, plastics can be incinerated as a municipal solid waste or used as a supplement with other municipal solid wastes to increase the combustion temperatures.

In the late nineties at Penn State University, University Park, PA, a team of faculty members which included an Ag Engineer, Horticulturist and Combustion Engineer initiated a project designed to recover the energy value of agricultural plastics through combustion and use the recovered energy for either heating or production of electricity. The process required 2 steps; one was the production of plastic nuggets from used agricultural plastics and two, combusting the nugget in a burner developed in Korea. The Korean burner required an ignitor source (fuel oil) and once the temperature of the burner reached 2,000 *F, the plastic in the nugget would melt to form a liquid that released a gas that was combusted in the burner with no toxic gases formed and minimal ash residue. The energy released from the combusted polyethylene could than be used to heat water for residential and/or greenhouse/high tunnel heating or produce electricity. To be energy efficient and sustainable, the burner would have to run 24/7 every day. The total amount of plastic fuel required to fuel the furnace was 150 lbs (68 kg) every 24 hours. The problem was that all the polyethylene and polypropylene that polluted both soil and water was difficult to collect since there were no mandates from state and/or federal officials.

By burning the solid wastes into ash, resource

Continued on next page

Agricultural Plastics; A Better Way to Recycle/Reuse and Be Sustainable (continued from page 119)

Table 1. Energy Value of Plastics, Municipal Solid Wastes, and Natural Resources

Material	Energy Value BTU
Plastic	
Polyethylene Terephthalate	9,000-9,700
Polyethylene	19,900
Polyvinyl Chloride	7,500-9,000
Polypropylene	18,500-19.500
Polystyrene	17,800
Municipal Solid Waste	
Newspaper	8,000
Textiles	6,900
Wood	6,700
Yard Wastes	3,000
Food Wastes	2,600
Natural Resources	
Fuel Oil	20,900
Wyoming Coal	9,600

Pyrolysis is the thermal degradation of plastic in an inert atmosphere. Pyrolysis results in hydrocarbons which can be used in the petrochemical industry as a feedstock or burned directly as a fuel source. Energy recovered from pyrolysis may be the most sustainable way to dispose of a highly mixed plastic types such as agricultural plastics.

recovery reduces the volume of waste entering the landfill by approximately 90 percent and recovers valuable energy that benefits all parts of society. In addition, resource recovery is inexpensive and can be financed in two ways. One way is for the plant to require a tipping fee--a charge to tip the dump bed of the waste hauler truck--which is approximately equal to the fee charged at a landfill. Second, revenue can be generated by selling the resulting energy to local electric companies. Besides these benefits, capturing the energy value of all of the waste generated in the U.S. could save as much as 60,000 barrels of oil each day.

Chemical Recycling

Chemical recycling is the only one of the four types of recycling that conforms to the principles of sustainable development because it leads to the formation of raw materials from which the plastics are originally made from with the recycled resin.

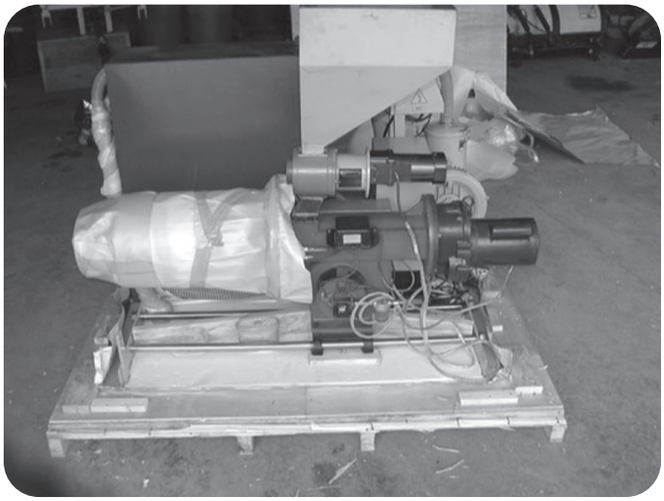
Pyrolysis is the most common form of chemical recycling. Pyrolysis is the thermal degradation of plastic in an inert atmosphere. Pyrolysis results in hydrocarbons which can be used in the petrochemical industry as a feedstock or burned directly as a fuel source. Energy recovered from pyrolysis may be the most sustainable way to dispose of a highly mixed plastic types such as agricultural plastics. The benefits of chemical recycling are clear; it is technically feasible to reconstitute recovered plastics from the agricultural sector to its original petrochemical constituents. This not only diverts agricultural plastics from the landfill but also generates useful resins for additional plastic products. Unfortunately, chemical recycling is not economically viable without significant subsidies because of the variable cost of petroleum.

Landfilling

Landfilling is the lowest cost option for the private and agricultural sector and in many cases,

Agricultural Plastics; A Better Way to Recycle/Reuse and Be Sustainable (continued from page 120)

Fig. 2. Prototype furnace from Korea that burns plastic nuggets at 2,000 degrees F and reclaim energy for heating or electricity. Photo courtesy of Dr. Bill Lamont.



the only option of plastic disposal in many rural areas. Ironically, landfilling exceeds the cost of incineration by twenty percent. In the United States, 80% of post consumer plastic and 90% of used agricultural plastic ends up in landfills. However, any polyethylene or polypropylene plastic will take decades to degrade. I have placed polyethylene films on raised beds in the 90's and yet today (2023) I can still find pieces of the plastic film (polyethylene) buried in the field. Also the leachate from landfills contains microplastic (MP) particles that create a serious pollution problem in urban areas and in bodies of water eventually ending up in the oceans. Obviously, landfills are not the solution for disposal of agricultural and consumer plastics and is certainly not sustainable.

Reuse

Some agricultural producers will actually reuse the plastic polyethylene film for more than one year if the film was initially 1.5 or 2.0 mil thick and has not been exposed to environmental conditions for more than 7 months in the field. This is also the case for drip tape greater than 8 mils in thickness.

Rigid plastics such as pots or trays can be reused for several years, however retail/wholesale nursery operations generally use a rigid plastic pot only once prior to the plant with pot being sold. The other problem is that rigid plastic pots come in a multitude of sizes, shapes and colors and many nurseries have their "branded" pots based on size, color and shape. Reuse of the rigid plastic pot is ultimately decided by the end user.

Can Agricultural Plastics Be Sustainable

Sustainability definition is the ability to maintain an ecological balance in our planet's natural environment and conserve natural resources to support the wellbeing of current and future generations. So, how can we help achieve sustainability with agricultural plastics based on the United Nations goals for sustainable development that act as the path to achieving a more sustainable future. These goals address global challenges like: life below water by avoiding the use of plastic bags to keep the oceans clean, life on land by planting trees to help protect the environment and reduce carbon dioxide and to promote and encourage waste to energy solutions especially for agricultural and consumer plastics. It has also been suggested by definition that sustainable farming should provide high-quality food to a growing human population and ensure food security and stability. It also helps farm owners to protect their health, while also trying to make the foremost use of supplies and preserving them for future generations and protecting the environment and saving the planet from agriculture's negative effects.

Conclusion

Unless their is global agreement by governments and manufacturers on sustainable methods to dispose of agricultural plastics, global pollution

Continued on next page

Agricultural Plastics; A Better Way to Recycle/Reuse and Be Sustainable (continued from page 121)

with plastics will only get significantly and visibly worse in the future. The projection for the use of plastics for both plant and animal production will only increase in future years to hopefully keep pace with an ever expanding population. In 2023, there were 12.5 million tons of plastics used in agriculture that led to an accumulation of large quantities of macro, micro and nano found in soils and bodies of water. Plastics can be used more sustainably in agriculture. The three largest countries that use large volumes of agricultural plastics are China, India and the United States. In 2021, world production of plastics was 391 million metric tons. Other countries or regions that use significant amount of agricultural plastics are Japan, Korea and western Europe. All these countries need to meet in the future to formulate a method(s) that dispose of agricultural plastics sustainably for future generations. Based on the previous research conducted at the Pennsylvania State University, the obvious solution in my mind is the waste to energy technology that demonstrated that polyethylene and polypropylene plastic film products could be burned in a specially designed burner at 2,000°F with very little ash deposits. Stack tests were also conducted to measure emissions from the combusted plastic film and it turns out that plastic film products burn cleaner with minimum harmful emissions to humans and the environment compared to coal.

Literature Cited

Bang, William Hunkyun (Seoul, KR), Paternostro, Thomas Anthony Patti (Stockton, CA, US) 2014 Burner system for waste plastic fuel United States 8833276 https://www.freepatentsonline.com/8833276.html

Garthe, J. W. . PlastoFuelTM Update - the right fuel right now. Proc. American Society of Plasticulture. 2009 Vol. 35 pp. 86-91

Garthe, J. W. and P. D. Kowal. Resource recovery: turning waste into energy. Penn State University Extension Publication. Updated: March 9, 2023. 8p.

Garthe, J. W., B. G. Millern, W. J. Lamont and M. D. Orzolek. Air emissions from fuel made of used agricultural plastics. Proc. American Society of Plasticulture. 2006. Vol. 33 pp. 16-22.

He, P. et al. Municipal solid waste (MSW) landfill: a source of microplastics? - evidence of microplastics in landfill leachate. 2019. Water Res.

Hoffman, Thio et al. Plastics can be used more sustainably in agriculture. Communications Earth Environment. 2023. 4:23.

Lawrence, M. J., J. W. Garthe and D. R. Buckmaster. A New look at making plastic-derived fuel - PlastoFuelTM Proc. American Society of Plasticulture. 2006. Vol. 33 pp. 87-93.

Orzolek, Mike. Editor. A Guide to the manufacture, performance, and potential of plastics in agriculture. 2017. Elsevier, Oxford, England 207p.

Qian, H. et al. Effects of soil residual plastic film on soil microbial community structure and fertility. Water , Air, Soil Pollution. 2018. 229:261

Wong, S, Ngadi, N., Abdullah, T. and Imuwa, I. Current state and future prospects of plastic waste as source of fuel: a review. Renew. Sustain. Energy Rev. 2015. 50. 1167-1180.