2020

MID-ATLANTIC
fruit & vegetable convention

PROCEEDINGS

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

BiO 360®

Biodegradable | Compostable Mulch Film

MATER-BI

Made from Mater-Bi

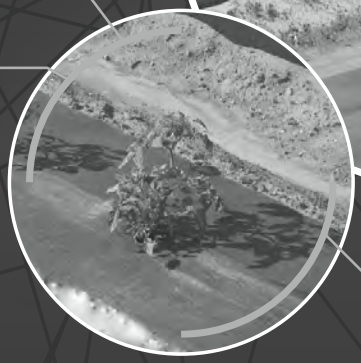
COMPOSTABLE IN INDUSTRIAL FACILITIES

BPI Certification

No negative impact on soil

Suitable for many types of crops

Several thicknesses available



Sustainably produced

Nolt's Produce Supplies
717-656-9764 - Leola, PA
noltsproducesupplies.net
For other regions, contact us
1-844-4BIO360 (1-844-424-6360)

EXPERIENCE 15 YEARS KNOW-HOW SUCCESS

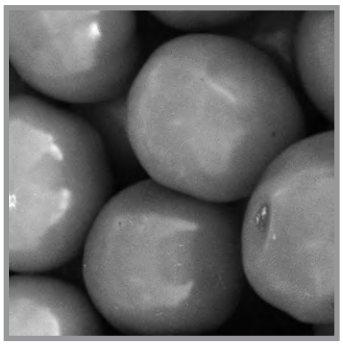
BiO 360®
Biodegradable | Compostable Mulch Film

2020 Mid-Atlantic Fruit and Vegetable Convention

Proceedings

FOR THE

VEGETABLE, POTATO, GREENHOUSE, SMALL FRUIT AND GENERAL SESSIONS



January 28-30, 2020

Hershey Lodge

Hershey, Pennsylvania

sponsored by

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

in cooperation with

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

Proceedings published by the

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

Pennsylvania Vegetable Growers Association

An association of commercial vegetable, potato and berry growers

TABLE OF CONTENTS

TABLE OF CONTENTS

ORGANIC VEGETABLE PRODUCTION

SWEET CORN

HIGH TUNNELS

POTATOES

LEAFY GREENS

CUT FLOWERS

GREENHOUSE VEGETABLES

SMALL FRUIT

MARKETING 101

HOT TOPICS FOR DIRECT MARKETERS AND VALUE ADDED PRODUCTS AND SERVICES

AGRITOURISM

DEVELOPING A SOCIAL MEDIA MARKETING PLAN

COMPOSTING OVERVIEW

Yichao Rui
Rodale Institute
yichao.rui@rodaleinstitute.org

Abstract

Composting is the controlled aerobic decomposition of organic materials. Many materials usually considered waste, including food scraps, animal manures, leaves, straw, and more can be composted. The resultant compost has numerous desirable applications, most notably as a soil amendment that increases soil biodiversity with a concomitant rise in biological services, such as nutrient cycling, disease suppression and soil structure enhancement (Ingham et al., 2000). Compost is a managed form of natural decay developed to address the common on-farm needs of soil quality/fertility and waste management.

Conventional farmers rely on costly synthetic fertilizers made from fossil fuel-intensive petroleum that can pollute local water supplies, harm wildlife, and deteriorate soil health. Organic farmers rely on inputs like compost instead. Not only does compost drastically reduce an organic farmer's need for chemical inputs, but the process of creating compost recycles farm materials, too. When incorporated into the soil, compost improves soil health and provides a diversity of microorganisms and nutrients that encourage healthy plant growth and development. Compost is an effective way to recycle while creating a valuable byproduct that feeds plants for healthy growth.

Solid waste generation in the United States continues to rise at a steady rate. According to the US Environmental Protection Agency, Americans generated about 254 million tons of trash in 2013, which is the equivalent of 4.40 pounds per person per day. Yard debris and food waste combined account for nearly 30% of the materials disposed in US landfills. These materials can be easily composted in municipal and backyard composting systems and fortunately, composting collection programs have been increasing with increasing waste generation.

Composting requires four basic elements: water, oxygen, nitrogen, and carbon. Generally, compost is comprised of piled subsequent carbon (brown) and nitrogen (green) rich layers, to which oxygen is incorporated by either passive means of aeration or through mechanical turning of the piled materials at various intervals. Over the course of time, a diverse range of microbes, both fungi and bacteria, work to decompose the substrate. Their metabolism creates a thermophilic environment and ultimately results in a mature humus free of biohazards and viable seeds but retaining vital nutrients (Howard, 1931; Keener et al., 2000). The heat generation from microbial metabolic activity, along with aeration and moisture content are important management factors affecting the nutrient retention and, relatedly, the levels of carbon, nitrogen and other gases released during the composting process (Beck-Friis et al., 2001). It may take a year or longer to generate finished compost depending on the materials added and how often the pile was turned. Woody materials will take longer to breakdown.

While the constituent substrate, climate and scale of the compost pile are important considerations in creating compost; decisions about the active management of the compost process are the greatest determinant of the final product's characteristics. Management choices made by farmers and others responsible for determining the composting process greatly influence the constitution of the compost microbe community, the environment that will dominant the process, and ultimately, the qualities of the final cured compost (Keener et al., 2000). As early as 1945, the consequences of compost management were known, if not quantified; in his prominent treatise on organic agriculture, Pay Dirt, J.I. Rodale stated:

Dr. Yichao Rui is a soil scientist with a focus on improving soil health and environmental sustainability through regenerative practices. Yichao oversees soil health research at Rodale Institute, supporting all short- and long-term projects. He also leads outreach initiatives to educate the public and farmers on the benefits of improving soil health. Yichao holds a B.S. in Biology from Nankai University and Ph.D. degrees in Microbial Ecology and Soil Science from the University of Chinese Academy of Sciences and Griffith University (Australia). Before joining Rodale Institute, Yichao worked in the University of Western Australia and the University of Wisconsin-Madison on a variety of projects evaluating the impacts of climate change, land use, and management strategies on soil organic matter stability, nutrient cycling, and microbial activity.

The [compost] materials must be handled in such a way that the microorganisms which break down the raw matter can do their work in the most efficient manner, and also prevent certain conditions from arising that give birth to outlaw organisms which putrefy, rather than compost, organic matter (p. 34).

Seeing how composting has become a more accessible, practical and possible waste management option at household, farm and municipal scales, it is in no one's best interest to complicate the composting process. However it is clearly beneficial to farmers, municipal compost facility operators, and the general public to efficiently produce compost with the least odor, the greatest carbon holding capacity and, by extension, which will give the greatest benefit to soil health wherever it is spread. For farmers, a composting process that retains more nutrients and more quickly builds soil organic matter with only slight management changes would be beneficial for waste management, soil fertility and crop productivity. For policy makers and the general public, finding inexpensive and easily implementable means to ensure food security for the future clearly a win-win.

From backyard composting, to farm and municipality scales, composting has become a popular means of diverting organic wastes from landfills, addressing farm mortalities and handling livestock manure (Kashmanian & Rynk, 1996). Over the past decade, composting on larger scales has become more common as municipalities seek economical and environmentally sustainable means of waste management (Vergara & Tchobanoglous, 2012). For instance, in the European Union, regulatory mandates to divert organic waste from landfills have created a new norm where large-scale industrial composting facilities recycle biowaste into a valuable soil amendment (Hultman et al., 2010; Sakai et al., 2011). In the US, the National Research Council's (2010) recommendations, complied in the report 'Towards Sustainable Agricultural Systems in the 21st Century,' cites composting as integral to the future of American agriculture. Traditionally, farmers have been avid composters. However, conventional cash grain crop agriculture in the US today, typified by large-scale mono-cropping, mechanization and chemical intensity, rarely engages in composting or utilizes compost as a soil amendment. Seeing as ¾ of all agricultural land in the US falls under this category (USDA, 2007), the scale of organic matter losses - from not composting- is far reaching.

BUSH AND POLE LIMA BEAN PRODUCTION AND HEAT TOLERANCE IN LIMA AND SNAP BEANS

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

Lima Bean Types

Lima beans were domesticated twice. The small seeded types (baby, sieva, butterpea) come from lima beans domesticated in what is now Mexico and Central America. Large seeded types (Fordhook, Dr. Martin, King of the Garden) are from the Andean region of South America. The small seeded types were grown by Native Americans in what is now the southwestern, south central and southeastern US before European contact, but the large seeded types were not introduced to US cultivation until the 1800s. This is important to note because the large seeded types available in the US descend from a narrow genetic base and are not as widely adapted as the small seeded types.

Growing Baby Limas

Most baby lima bean varieties have a bush growth habit. They should be sown at 3" spacing in 30" rows after danger of frost and when soil temperatures are above 65°F. Nutrient recommendations may be found in the Mid-Atlantic Commercial Vegetable Production Recommendations. Fertility requirements are slightly higher than for snap beans. Lima beans have a robust root system, but in light soils they benefit from irrigation during dry spells.

Lima bean downy mildew (Phytophthora phaseoli), white mold (Sclerotinea) and lima bean pod blight (Phytophthora capsici) can be problematic depending on locality, but can be controlled with fungicides. Stink bugs are a common pest problem and their feeding can reduce yield by causing pods to drop. Other pests that can affect snap bean (potato leafhopper, Mexican bean beetles) are rarely a problem in baby lima beans.

Baby limas will take 70-85 days to reach succulent stage harvest. Snap bean harvesters can be used for small-scale mechanical harvest or pods can be harvested by hand. Many varieties will flower continuously, and multiple pickings are possible if hand harvested.

Growing Fordhook Limas

Fordhook 242 is the widely available plump large seeded lima variety. It should be sown at a 6" spacing in 30" rows after danger of frost and when soil temperatures are above 65°F. The large seeds are susceptible to attack by soil insects and pathogens and soil crusting can cause emergence problems. Achieving a good stand is dependent of planting when conditions are right for quick emergence (warm soil, adequate soil moisture, no heavy rain expected). Fertility and irrigation requirements and pest and disease concerns are the same as for baby limas. Bacterial brown spot (Pseudomonas syringae pv. syringae) can be a problem in wet years. Copper fungicides are the only labeled control. Fordhook 242 will take 90-100 days to reach succulent stage harvest.

Growing Pole Big Limas

Vining big limas, such as Dr. Martin or King of the Garden, should be grown on a trellis that is ~6' tall. Seeds should be started indoors (bottom heat recommended) and transplanted when the primary leaves are fully expanded. In row spacing is 4-6'. Spacing between rows should be at least 5'. Trellis systems must be sturdy to support the heavy weight of vines. Plastic mulch or straw can be used to suppress weeds in the row. Irrigation is necessary in light soils and recommended for other conditions. Plants will require 1.5-2.5 inches of water per week during pod set and pod fill.

Emmalea Ernest is an Associate Scientist working with the University of Delaware Extension Vegetable and Fruit Program. She has worked in this position since 2004 and conducts variety trials and crop management research with a variety of crops and breeds new varieties of lima beans for the Mid-Atlantic region. Emmalea is originally from southern Lancaster County, Pennsylvania. She earned a B.S. in Horticulture from Penn State University, an M.S. in Plant Breeding and Genetics from Michigan State University and recently completed a Ph.D. in Plant Science from University of Delaware. She and her husband Jeremy have two daughters.

Use nutrient recommendations in the Mid-Atlantic Vegetable Recommendations as a guideline. Additional N fertilizer may be necessary if leaching rains occur or if the harvest period is extended. Stink bugs are a frequent pest. Spider mites, aphids and Mexican bean beetle can sometimes cause problems. Lima bean downy mildew, and bacterial brown spot are the most common disease problems.

Under favorable conditions, May-planted big limas will produce some pods in July. Heat often delays harvest until August or September. Harvest will continue until frost.

Heat Stress Effects in Lima and Snap Bean

Both lima and snap beans are sensitive to high night temperatures (>70°F). High daytime temperatures are not as damaging if soil moisture is adequate. Hot nights are especially damaging during the early flowering stage, just after the first flowers open. At this stage, high night temperatures cause damage to anthers in the developing flower buds. Later, when flowers open the anthers do not release pollen and seed set is reduced or totally inhibited. Symptoms of heat stress at this stage in snap bean are: reduced pod set, split pod set, curved and short pods with missing seeds. In lima bean symptoms are reduced pod set, split set, delayed maturity and fewer seeds per pod. In some varieties, heat stress after pod set can interfere with seed filling. In snap beans this results in small pods that do not develop seeds and in lima bean it causes small and misshapen seeds.

Management Practices to Avoid Heat Stress

Drought stress will exacerbate heat stress because the plant cannot cool itself through evapotranspiration. Maintaining adequate soil moisture during heat events is very important. Depending on your marketing plan, you can attempt to time plantings to avoid hot periods during flowering.

Using Heat Tolerant Varieties

Some heat tolerant snap bean varieties are available. Based on trials conducted in Delaware in 2017 and 2018 the varieties PV 857, Annihilator and Dominator maintain high yield and high quality when exposed to heat during and after flowering. Large seeded (Andean) lima bean varieties are heat sensitive including Fordhook 242, Dr. Martin, King of the Garden and Big Momma. Christmas Lima is the most heat tolerant large lima that is widely available. Small seeded limas are generally more heat tolerant, although some of the green-seeded baby types are heat sensitive.

PEST AND DISEASE MANAGEMENT CONSIDERATIONS

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

Pest and diseases can be a significant constraint to vegetable production reducing both yield and marketability so using preventative and proactive management strategies are important. It is also important to be familiar with recognizing common diseases and insect pests on your crop; to be scouting and monitoring for them throughout the season; and to know what in-season management tools are available to slow disease development or knock back insect pest populations when they reach threshold levels to cause economic injury. Being able to distinguish beneficial insects/natural enemies from pests as well as understanding the pollinator needs of your crops is also important.

For plant diseases to develop, the three factors that must overlap in a Venn diagram and constitute the three corners of the disease triangle include: 1) a susceptible host crop; 2) the pathogen and 3) an environment that is favorable for the pathogen. All disease management strategies can be related back to breaking or disrupting one or more of these interactions.

Insect pests are highly dependent on temperature to drive the completion of their lifecycle because they are ectothermic, so outside temperatures regulate their temperature. As a result, growing degree-days are often used to estimate insect development based on a biofix (a specific biological event in the insect lifecycle) such emergence in spring and can be used to time scouting and the application of in-season management tools.

The most effective disease and insect pest management programs are integrated using multiple tactics to break-up the lifecycles of pests and pathogens; a concept known as integrated pest management (IPM). IPM focuses on the use of cultural, mechanical, physical and biological tactics before the use of chemicals and then within the use of chemicals selection of biorational products over conventional pesticides when possible. More recently, this concept has been expanded to include additional components related to economic viability, social acceptance and environmental safety as well as placing additional emphasis on pest monitoring and communication not only among growers but also the public. Below are some of components to consider when developing and implementing a pest and disease management program.

Host plant resistance is an important tool for managing both diseases and insect pests. Cultivars vary in their morphology, physical and biochemical characteristics that making them more or less susceptible or attractive. Resistance does not imply immunity but rather a reduction in potential damage or a delay in disease symptom development thus for diseases reducing the number of fungicide applications needed during the season. Host resistance can be very specific and be dependent on the strain or race of a pathogen so accurate diagnosis and historical disease records are helpful in selecting cultivars. For example, there are over ten races of the bacterial pathogen that causes bacterial leaf spot on pepper, one of the most common and destructive diseases on pepper. Different cultivars of pepper contain different combinations of resistance genes and therefore are resistant to different pathogen races. The X10R peppers contain two resistance genes that confer some level of resistance to all the currently recognized races

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

of the pathogen however, new races continue to evolve. Resistance to European corn borer (ECB) that is present in many of the field and sweet corn cultivars has driven down the pest population to the point where ECB is not considered a pest on peppers in the region. This could however, change should ECB evolve to overcome that resistance. For a list of recommended cultivars for our production region and their corresponding pest and disease resistance see the 2020/21 Commercial Vegetable Production Recommends.

Cultural strategies encompass a lot of preventative best practices that focus on promoting plant and soil health, creating environments that are less favorable for pests and diseases through optimizing plant nutrition, row spacing, reducing leaf wetness and soil splashing as well as sanitation. Sanitation should be considered throughout the production cycle from seed selection and transplant production through the management of post-harvest crop residue. Crop rotation with non-hosts also plays a key role in breaking up pest and pathogen lifecycles. Rotations out of plant families for at least 2 to 3 years is recommended however, longer rotations may be necessary for certain soilborne pathogens that can survive in the soil long after the crop residue has been thoroughly decomposed. Rogueing symptomatic fruit and sanitation of equipment can reduce the spread of certain diseases such as Phytophthora blight on cucurbits and peppers.

Biological control typically focuses on the use of natural enemies such as parasitic wasps or predatory mites to reduce insect pest populations whether trying to conserve native natural enemy populations using refuges or by releasing reared biocontrols in a greenhouse or high tunnel. In some cases, insect pests such as the tomato hornworm can be managed solely through native Braconid parasitic wasps and the occasional hand removal. Microbes can be used to manage plant disease causing organisms. They are most often formulated into products and applied at various points during crop production from drenches at transplanting to in-field foliar applications. They have a wide array of modes of action and are best applied preventatively. These can include fungal organisms such as Trichoderma spp. or bacteria such as Bacillus spp.

In-season product applications can range from biorational products that include microbial-based, biochemical-based as well as conventional products. The objective of using these products is to reduce insect pest populations below the economic injury level and reduce the production of secondary inoculum for many foliar diseases such as powdery mildew, early blight and downy mildew, etc. Accurate pest and disease identification are critical for selection of the most effective products especially those with a single-site mode of action. It is recommended that you contact your local extension office or submit a sample to the plant disease clinic at your land-grant institution for help in identification, if needed. Managing for resistance should always be a consideration when developing insect and disease insecticide and fungicide programs.

Knowledge and resources are important for helping to make informed management decisions. In addition to accurate pest and disease identification described previously, monitoring and scouting are important not only on a field and farm level but also a regional level. There are many resources to help during the season including PestWatch (www.pestwatch.psu.edu) which is a regional monitoring network for corn earworm, European corn borer, fall armyworm, and Western bean cutworm. The Cucurbit Downy Mildew ipmPIPE network (www.cdm.ipmpipe.org) uses confirmed disease reports as well as the forecasted weather to create risk maps to help growers time fungicide applications. There is also the USAblight.org (www.usablight.org) network for monitoring where late blight has been confirmed at the county level and what pathogen genotype was detected. This information along outbreaks of other insect pests and diseases of vegetables are also reported in Penn State Extension and PVGA newsletters, pest and disease alerts and the 1-800-PENN-IPM hotline. Regularly updated pest and disease information is also available at most of the PA produce auctions. Regular scouting. knowing what pests and diseases are being observed in the region and what management options are available are critical components of a successful IPM program.

ECONOMICS: TO TUNNEL OR NOT TO TUNNEL

Lynn Kime
Penn State Extension

This presentation compares the income from producing tomatoes in a high tunnel to producing tomatoes on open land using plasticulture. We consider the added expense of the high tunnel and producing either earlier or later in the season to the lower input costs of producing on open land.

When producing tomatoes in a high tunnel many of the costs are the same as producing conventionally on open land. We will attempt to tackle the questions of crop rotation in the tunnel and the build up of salts from covered land and what these added concerns may cost? Will the added cost of the tunnel be offset by the increased prices received for the products sold?

We will consider the cost of production on open ground and the possible reduced income from marketing tomatoes when other producers are also selling their crop. This market saturation may reduce the potential price, impacting profitability.

Two enterprise budgets will be developed to demonstrate the potential differences in profitability between production practices. These budgets will be adaptable to individual farms for specific analysis by each producer. These budgets will be available on the Penn State Extension web site at: https://extension.psu.edu.

Lynn Kime is a Senior Extension Associate and project coordinator for the Agriculture Alternatives publication series for the Department of Agricultural Economics, Sociology, and Extension Education of Penn State. He is also the team leader for the New and Beginning Farmer Team and works closely with educators to develop educational materials for this clientele. He works extensively in the area of budgeting for crops, livestock, and horticulture. Lynn also works in the areas of crop insurance education and is a co-author of the Your Future in Focus and Farm Sense courses.

SWEETPOTATO IN PA: THE ROADMAP FOR ADAPTATION AND ADOPTION BY STAKEHOLDERS

Luis Duque, Ph.D.
Department of Plant Science, Penn State University, 109 Tyson Building,
University Park, PA 16802. Email: loduque@psu.edu

Introduction

Sweetpotatoes are typically grown for fresh market consumption, but they are increasingly being utilized for value-added alternative markets such as processed foods and industrial products among others. In the U.S., different varieties of sweetpotatoes, for example, orange-fleshed as well as purple- and cream-fleshed are increasing in availability and quality. According to the 2017 USDA/NASS Ag-Census, the Northeast accounts for ~1600 acres harvested stemming from over ~818 farms, a 19% increase from 2012.

Pennsylvania's sweetpotato acreage is slowly, but steadily growing and now accounts for over 9% of the a harvested in the Northeast. PA's greatest challenge for sweetpotato production is due to shorter growing seasons, average milder temperatures, types of soil, inadequate farm infrastructure, post-harvest handling and market opportunities.

Adaptation Trial

During the 2018 and 2019 growing seasons, we completed two trials with a total of 10 sweetpotato varieties with different skin and flesh colors (Table 1). These varieties were examined for adaptation under central Pennsylvania growing conditions.

All planting material (slips) were provided by the Sweetpotato Breeding and Genetics Program from North Carolina State University. Upon arrival to Penn State University, Generation 2 (G2) planting material was inspected, sorted and bundled for each respective trial. Both yearly trials were carried out at The Russell E. Larson Agricultural Research Center at Rock Springs, PA. Field sites were prepared according to farm protocols. First, a burn-down herbicide was sprayed on the field, then soil was chisel-plowed, disc-harrowed and finally, rototilled. Field fertilization was unnecessary as soil testing results gave above-optimal soil fertility conditions. Afterwards, raised beds were prepared and covered in black plastic mulch and underlaid with drip tape used for fertigation. Final raised beds were 36" wide with 5' center-to-center rows. All slips were planted at 12" spacing with 10 plants per experimental plot using a randomized complete block design for a calculated total of 8712 plants/acre. All trials were planted during the last week of May for both years after soil temperatures reached above 60 °F (under plastic mulch). During both growing seasons, irrigation and manual weeding was performed as needed.

Results

After 120 days in both years (2018 and 2019), all plots were harvested, sorted and weighed by grade: U.S. #1, Jumbos, Canners and Culls. In general, total marketable yield (TMY) for 2018 was statically higher when compared to 2019 for all varieties tested. Overall, 2018 TMY was 455 bushels/acre (11.3 tons/acre) compared to 355 bushel/acre (8.9 tons/acre) for 2019. Likewise, U.S. #1 yielded 311 bushels/acre (7.8 tons/acre) for 2018 and 257 bushels/acre (6.4 tons/acre) for 2019, respectively (Table 2).

When comparing variety performance, Beauregard TMY ranked first in 2018 followed by Orleans, Covington and Averre (no statistical difference between the latter three). However, in 2019, Orleans TMY ranked first, followed by Beauregard, Covington and Averre (also, no statistical difference between the latter three). With regards to U.S. #1 yield, 2018 out-performed 2019. Specifically, Covington, Averre, Beauregard and Orleans yielded between 20-25 lbs. of U.S. #1/plot (yield of 10 plants/plot) for 2018 compared to 15-20 lbs. of U.S. #1/plot for 2019 (Figure 1).

Dr. Luis Duque is a storage root crop physiologist and faculty member of the Department of Plant Science at Penn State University. He received his Master's, PhD and post-doctoral training from Cornell University. Dr. Duque's research focuses on a better understanding of the influence of abiotic stresses on crop growth, development and yield of storage root crops, mainly Cassava (Manihot esculenta Crantz) and Sweetpotato (Ipomoea batatas Lam.).

These results suggest that Beauregard, Covington, Orleans or Averre (all orange-fleshed varieties) are good choices for Central Pennsylvania farmers with regards to both environmental and soil adaptations. With regards to the other varieties tested, Carolina Ruby (OF), Murasaki (WF), Bonita (WF) and P13-0030 (PF) presented decent TMY and can be adopted by farmers to ensure a mix of flavors, textures and colors for future emerging markets.

Variety/Clone	Origin	Skin Color	Flesh Color
Averre	NCSU	Rose	Orange (OF)
Beauregard	LSU	Light Red	Orange
Bonita	LSU	Tan	White (WF)
Carolina Ruby	NCSU	Red	Orange
Covington	NCSU	Rose	Orange
Japanese	Japan	Purple	White
Murasaki	LSU	Purple	White
NC413	NCSU (unreleased)	Purple	Purple (PF)
Orleans	LSU	Light Rose	Orange
P13-0030	NCSU (unreleased)	Purple	Purple

Table 1. Varieties tested during the 2018 and 2019 field seasons

VARIETIES	2018							2019						
	U.S. #1's (1)	Jumbos (1)	Canners (1)	Culls (1)	TMY (1)	TMY (2)	TMY (3)	U.S. #1's (1)	Jumbos (1)	Canners (1)	Culls (1)	TMY (1)	TMY (2)	TMY (3)
Averre	23.7	4.5	3.3	5.0	31.5	548.0	13.7	15.7	0.9	3.3	0.6	20.0	347.8	8.7
Beauregard	24.0	12.2	4.3	7.3	40.5	706.3	17.7	16.0	1.9	1.9	0.9	19.8	344.3	8.6
Bonita	14.3	0.3	8.8	1.5	23.3	406.4	10.2	13.8	0.5	6.5	0.7	20.8	361.8	9.0
Carolina Ruby	15.8	2.5	6.6	4.6	24.8	431.9	10.8	15.0	0.4	4.0	2.4	19.4	337.2	8.4
Covington	24.0	3.6	5.1	8.7	32.7	569.1	14.2	14.0	0.5	5.2	0.0	19.7	343.0	8.6
Japanese	•	•	•	•	•	•	•	12.2	2.8	3.5	0.3	18.4	320.6	8.0
Murasaki	14.1	2.7	1.7	1.5	18.6	323.5	8.1	•	•	•	•	•	•	•
NC413	1.7	1.6	1.5	6.7	4.7	82.1	2.1	•	•	•	•	•	•	•
Orleans	25.3	4.4	3.6	6.6	33.2	579.1	14.5	18.1	2.3	4.5	0.8	24.8	432.8	10.8
P13-0030	•	•	•	•	•	•	•	13.5	2.0	4.8	1.0	20.3	353.5	8.8

Table 2. 2018 and 2019 sweetpotato varieties yields per grade. (1) lbs./10 plant plots; (2) bushels/acre; (3) tons/acre

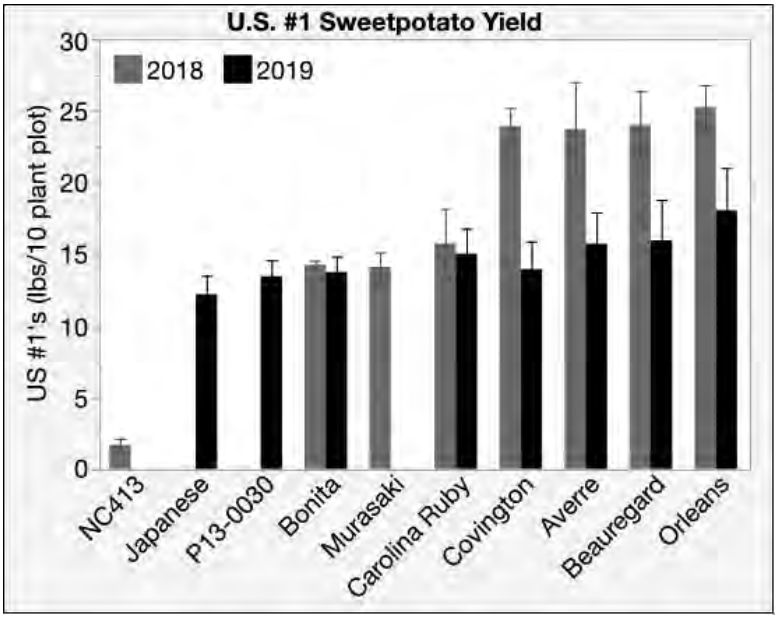


Figure 1. U.S. #1 yield per 10 plant plots for all varieties tested in 2018 and 2019.

SWEETPOTATO PRODUCTION – A SOUTHERN PERSPECTIVE ON VARIETAL DEVELOPMENT, CULTURE, NUTRITION AND TREND

Don La Bonte
Louisiana State University AgCenter, 104 Sturgis Hall, LSU Campus Baton Rouge, LA 70803
dlabont@lsu.edu

Varieties Lots to choose from….

White Flesh – Surprising how much is grown and sold in the U.S. – most of it comes out of California. The Northeast has always been a popular spot for white flesh sweetpotatoes. Just about everywhere outside of North America eats a white flesh sweetpotato – so keep this in mind. I have found people are very clear on like and dislike for white flesh varieties - no in-betweens!

Bonita – Flaky texture and nutty taste. A pinkish skin that fades to tan. For purists there is a white skin version, but I don't like it as it shows imperfections, but that's what a sweetpotato looks like in most of the world. It has excellent disease resistance and flooding tolerance. Shapes nicely in heavy and sandy soils – unusual. Excellent yield, but watch sizing as it can jumbo quickly and not much of a market out there for jumbo whites (or sweets as they call them in California). Things we have learned. A tight spacing cuts down on jumbos, but watch roots emerging from soil and the tips greening at this spacing – can't have it both ways. Nothing bad like green potatoes health wise, but customers won't buy them.

Murasaki-29 – (purple in Japanese). Purple skin, bright white flesh. A strong following. Doubles as an Asian and boniato - popular in Hispanic markets. A nice chestnut flavor. Be patient – it takes time to size and expect an extra 2 weeks over other varieties. Planting early does not solve the problem as it really likes a warmer environment to start and optimize yield. Think early June. A great organic as resistant to disease, nematodes, and insects. This is a high dry matter variety so expect lower yield. Loves sandy soil and a bit round in heavy soils.

Orange Flesh – A big list, but let's look at the major ones.

Covington - The most popular variety grown on the East Coast. I like the nice consistent shape and does well if you irrigate. The high root count does set you up for a late harvest and expect a crop to size 10+ days beyond other orange flesh varieties. Covington has nematode resistance. Really likes a sandy soil; we don't grow it in the Gulf South as our soils are just too heavy.

Evangeline – Looks a lot like Beauregard except redder, but more consistent shape. This is THE go to sweetpotato variety in the Gulf South for that heirloom like taste. Always commands a much higher price in farmer markets/roadside sales. People ask for it by name and will pay $$. Has a deep orange flesh and high sucrose content so extra rich taste and sweet. Really our best tasting sweetpotato. Lower yield than Beauregard, but better shape gives you more marketable roots than Beauregard so nice trade off. Flooding tolerant and nematode resistance. It is not a good sprouter in plant beds – need to bed very shallow and bed after cold weather passes. Hard to get plants, but might try Glover farms

Don La Bonte is a native of Springfield, Illinois and graduated from the University of Illinois with a PhD in plant breeding and genetics. Don is a Professor at the LSU AgCenter and develops new sweetpotato varieties and conducts genetic research on sweeetpotato. Don teaches a graduate level course on advanced plant genetics and an undergraduate course in plant physiology. He also serves as the Director of the School of Plant, Environmental, and Soil Sciences. Don and his wife Diane have two daughters Bridget and Kara.

Interesting tidbit – the high sucrose content makes Evangeline a perfect microwaved sweetpotato. Tastes almost like a baked sweetpotato – really! No one grows it for this purpose though - hmm.

Orleans – A Beauregard look alike in flavor and taste appearance. Really the only difference is a higher grade out of U.S. #1 – less scrappy stuff. Probably won't notice quality improvement over Beauregard if you grow just a bit.

Radiance - A release from Vineland Research Centre in Ontario Canada. We have been working with Vineland to breed a variety more suitable for a colder climate. Nice classic Beauregard look and taste - maybe just a bit more reddish hue. We have seen comparable yield in Gulf South to our main varieties so definitely worth a try! Good results in the colder Canadian climate.

Something different to sell
Sweetpotato young leaves and plant tips are eaten throughout the world. Salad or a stir-fry. Surprisingly has a high lutein content similar to spinach so not just ruffage. Nothing produces more foliage than sweetpotato except maybe pumpkin! Interesting tidbit – A company in Europe sells etiolated root sprouts (grown in low light so a bit whitish). Maybe a good use for those reject root!

Trending
What we used to term a canner (#2 grade) sells just as well as a #1. We call it a petite #1. Mix some orange with some white flesh roots in a medley for sale as a bagged product. Speaking of bags – our traditional 40 pound box is just about to slide into second place behind bags and wraps.

….If only I had known…. OR ….next year I will……

This is a ***tropical plan***t – it really does not like cold. If your soil temperature is below 60 F and your day temp is below 60 F – DO NOT PLANT. The plant will just sit there and deplete what little sugars are there and you will never get the yield you want. I do expect your soils to stay colder longer. Maybe, just maybe a higher air temperature compensates for a persistent cold soil. Kind of see that in Canada. Go with the air temperature in the North East. Our Louisiana growers always say, "never plant in a north wind" – makes sense and now we know why.

Ideally you want two to three nodes in the ground so you really need a decent plant length. One node just does not do it. I think your soil is well suited for a horizontal planting like they do in Australia, i.e., plant 4-5 nodes parallel to the surface of the soil, but be sure you have decent amounts of foliage above ground. Try a few plants like this.

More above ground foliage at planting is better than less. Better establishment – just that simple.

The first 10 days is the most important. ABSOLUTELY TRUE. We have found those little white roots emerging at the nodes are not feeder roots, but the roots which become storage roots. IF you keep the soil at 50% field capacity then these white feeder roots will become storage roots. Otherwise they stay as pencil sized roots. Your choice. That temperature water combination is so important to getting high yield. Once you get through this critical time period, a little drought is not harmful – they just stop growing, but will pick up where things left off when it rains again.

Spend that extra on quality plants. Only buy plants from a certified seed grower. The Guava Root Knot Nematode is well established in North Carolina. You do not want this nematode on your land.

More fertilizer = more yield? There is a good reason sweetpotato is a fantastic subsistence crop in much of the world. It just does not need much fertilizer. Think tomato – if you over fertilize you get more foliage and less fruit. Same here. The phosphorus will give you length so if your P levels are low expect rounder roots. Potassium will give you girth, but If your potassium is too high expect over the top foliage production and lower yield. TIP…after 80 days you will see the foliage start to yellow a bit – don't panic. The nutrients are being remobilized to the roots so DON'T add any foliar feed – a waste of money and confuses the plant.

Typical nutrition levels. Remember... Your application rate depends on what's already in the soil so do a soil test.

INCORPORATE – best to mix up the soil with the fertilizer. Makes a big difference.

Sweetpotato likes a more basic soil 6 or more…

Nitrogen – 78-89kg/ha or 70-80 lbs per acre. Do a split treatment at planting and band 60 days after planting. Sweetpotatoes are picky and like nitrate forms over ammonia – particularly Evangeline. Seems to burn those delicate emerging roots.

Phosphorus – 100 to 112 kg/ha or 89-100 lbs per acre. Soils often have appreciable P so watch it.

Potassium – 134 to 168kg/ha or 119 to 149 lbs per acre.

Licensed and certified plant sellers / seed root suppliers – North Carolina

(Wade) Glover Farms rwgfarming@gmail.com

Jones Family Farms Jessica Williams jessica@jonesfarmsnc.com

ALLIUM LEAFMINER : WHEN AND HOW TO CONTROL

Shelby J. Fleischer, Timothy Elkner, Brandon Lingbeek, Lauren Briggs
Department of Entomology and Penn State Extension
The Pennsylvania State University, University Park, PA 16802

The allium leafminer (ALM) reached the Western Hemisphere by December 2015 and is now confirmed in 5 states. It is a small fly that is a specialist on plants in the Allium plant genus. Farms with a continuous supply of allium hosts, such as chives, onions, leeks, garlic, as well as weedy alliums, provide a host for both the spring and fall generation, and these farms may be most at risk.

Fig. 1: ALM oviposition marks. Photo: C. McGrady

ALM overwinter as pupae either within or in close association with leaf or bulb tissue. Adults emerge early in the spring. The eggs develop into larvae (maggots) that mine the leaf tissue, moving downward into the swollen leaf base that makes up the bulb, or into the stem of leeks. Mines can be difficult to find. The larvae develop into pupae, which stop or dramatically slow development. Thus, these summer pupae undergo a summer aestivation until fall. The pupae eventually restart their development, and hatch out as adults, in the fall.

Knowing *when* adults are first emerging, and when adult flight ends, can help time chemical and cultural management options. We measured the timing of adult flight by scouting hosts on farms, and on sentinel plots during the spring (Apr. through May) and fall (Sept. through Nov.) generations. We used these data to develop a degree-day prediction for when adult flight starts in the spring. We also took x-rays of ALM puparia stored at different temperatures to examine development from larva to pupa.

Active scouting, including scouting wild Allium species, is the best method to detect first emergence of ALM: emergence cages did not match ALM activity in the field and portable trays of alliums sustained little damage. **Using field-collected pupae reared in the lab, plus a statistical method, suggests that spring emergence starts at 250 Celcius degree-day, using a lower developmental threshold of 3.5 degrees Cel-**

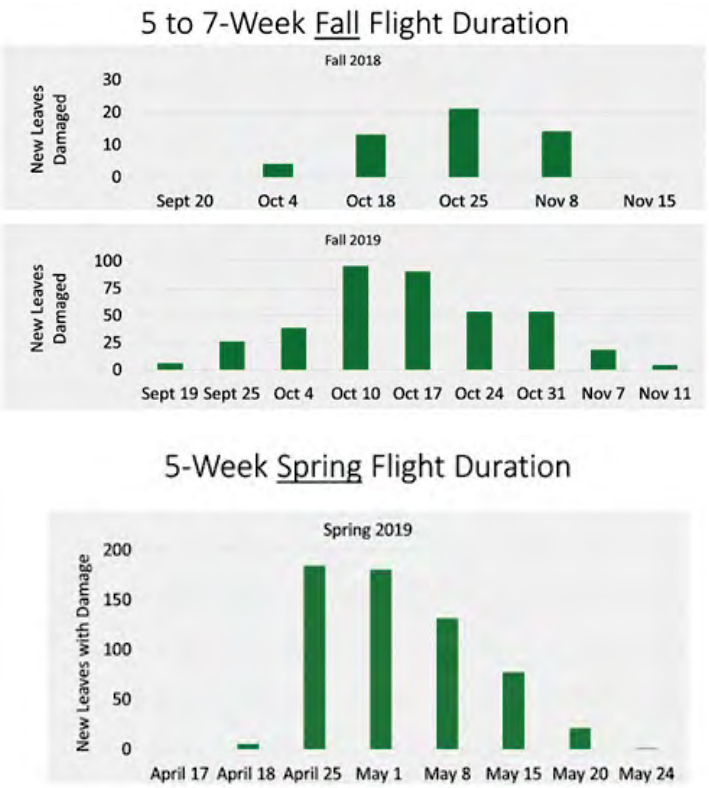


Figure 2. Adult ALM flight duration.

Dr. Fleischer is on the faculty of the Department of Entomology at The Pennsylvania State University where he specializes in population dynamics of insects. He has been worked in vegetable agroecosystems for 28 years. He previously was a Research Scientist at Virgina Tech and Research Associate at Auburn University. He received his B.S. in Biology from St. Mary's College of Maryland, his M.S. in Entomology from Virgina Tech and his Ph.D. in Entomology from Auburn. A native of Washington, D.C., he and his wife Barbara have two daughters and four grandchildren.

sius. These values also were very close to the optimum solution when using only field scouting data, although another solution (0.5 C lower threshold, and 400 degree-days) was slightly better. We plan to trial this degree-day model to alert growers to when to expect initiation of the spring emergence. Following emergence, flight duration occurred over 5-7 weeks (Figure 2). Development from egg to pupae took 5 days at 22°C, 21 days at 4°C and 40 days at 30°C resulted in one hundred percent mortality (Figure 3). Pupal development was also a function of temperature.

We've seen differences in the risk of infestation among different Allium species. We've seen higher rates of oviposition marks on scallions compared to leeks, but we recover similar numbers of ALM when we dissect these plants later in the season. In a field setting, when given a choice among different ages of scallions in the fall, the youngest scallions resulted in the highest ALM infestation. However, in transplanted 'Candy' onions, grown in the same method as in the Simply Sweet® program, the opposite occurred: in onions present during the spring flight, the oldest onions, with the most leaf tissue, resulted in the most infestation. **In general, if growers are looking for a trap crop, healthy actively growing scallions look like a good choice.**

We've also seen **strong differences in how ALM develop within different allium hosts**. Within leeks, we pull out larvae deep within the harvestable stalk that is used for sale. Our top record, so far, has been >50 ALM within a single leek. In contrast, almost all the ALM we have dissected out of 'Candy' onions were in one of the scale leaves: the outermost leaves that dehise as the plant moves into a 'bulbing' growth stage and form the papery coating on the outside of the plant (Fig. 4). The very low occurrence of ALM to onions that were planted following the timing and methods used for the 'Simply Sweet' production was concentrated in the outer leaves that senesce during bulb formation and thus become the scale leaves (the outer 'papery' coating that surrounds the bulb at harvest). We do not know if this is due to the timing of infestation given the plant growth stage when 'Simply Sweet' onions are transplanted, or the way in which larvae feed within the hollow onion leaves, or a combination of both. Regardless, **this suggests that risk to infestation in bulbs of 'Simply Sweet' production is low. Risk to scallions and leeks is high.**

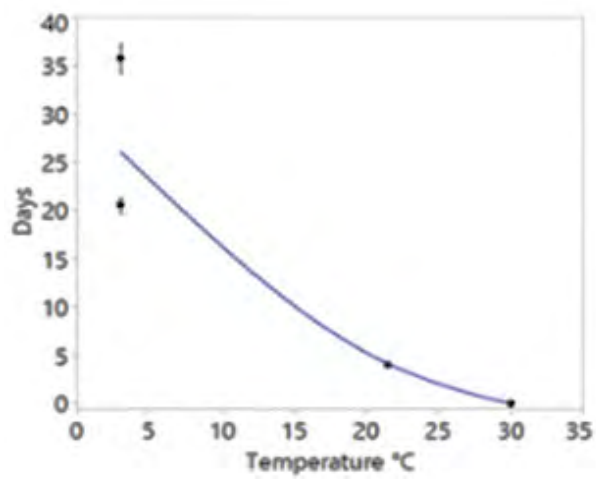


Figure 3. Egg to pupal development rate of ALM as a function of temperature

We've conducted **efficacy trials with conventional and organic insecticides (Tables 1 and 2).** Efforts to test insecticides in onions failed. Although we could document adult activity on onions via oviposition marks, we had virtually no larval or pupal infestations in the bulbs (as noted above, the few ALM in the bulbs were in the scale leaves. However, we have had clear results from trials in leeks (Tables 1 and 2), where ALM activity is high (defined as % infested plants) ad larva and pupae recovery is high. Among conventional options, we are getting highest efficacy with systemics, both neonicotinoids (IRAC 4A options) and diamides (IRAC 28 options), and Radiant. Foliar sprays have worked better than application through the drip in leeks. Among the OCIA-labelled options, we've had control with Entrust and Aza-Direct.

Fig. 4. ALM embedded in a scale leaf of a 'Candy' onion. Photo: B. Lingbeek

Table 1. Insecticide evaluation in leeks, 2018. Application dates were based on adult flight activity and label allowances. Treatments using drip were applied on 9/24 and 10/24. All other treatments were foliar applications applied on 9/26, 10/2, 10/26, 10/31, and 11/4.

Product	Rate Ounces/Acre	% damaged plants[a,b]	Avg. no. ALM/plant[a,c]
Pyganic	32	82.5 a	2.725 a
Control	---	55 a	1.525 b
Verimark Drip	10	40 a	0.85 bcd
Azera	48	42.5 a	0.825 bc
Aza Direct	48	50 a	0.7 bcd
Scorpion Drip	10	35 ab	0.675 bcd
Scorpion Foliar	20	10 bc	0.15 cd
Exirel	20	10 c	0.1 d
Radiant	10	10 bc	0.1 d

[a] Means followed by the same letter are not significantly different (P> 0.05; Tukey's Studentized Range [HSD] Test; n= 4). Damage data were transformed using a sqrt (x + 0.001) function and insect count data were transformed using log (x + 1) function before analysis, but untransformed means are presented.

[b] A plant was considered damaged if it had ≥ 1 larva or ≥ 1 pupa.

[c] Included both larvae and pupae.

Table 2. Insecticide evaluation in leeks, 2019. Application dates were based on adult flight activity and label allowances. The 'Off Label Entrust' involved Entrust applied more than the seasonal allowable amount according to the label.

Treatment	Rate Fl oz/A	Spray Dates	Avg. no. ALM/plant	% damaged plants
Control	----	---	16.600 a	1.000 a
Entrust	6.0	25-Sep, 11-Oct	8.400 b	0.850 a
Radiant	10.0	25-Sep, 4-Oct, 11-Oct	5.125 bc	0.875 a
Exirel	20.0	25-Sep, 4-Oct, 11-Oct	5.025 bc	0.575 b
Aza-Direct	48.0	25-Sep, 4-Oct, 11-Oct, 21-Oct, 28-Oct	5.100 bc	0.775 ab
Scorpion	5.25	25-Sep, 11-Oct	3.875 c	0.875 a
Off Label Entrust	6.0	25-Sep, 4-Oct, 11-Oct, 21-Oct	1.225 c	0.525 b

Finally, a longer-term solution is biocontrol. In its native range in Europe, ALM is parasitized by multiple species of wasps, and we've confirmed two species of parasitoids from ALM in Pennsylvania.

STEMPHYLIUM LEAF BLIGHT MANAGEMENT IN ONIONS

Sarah Pethybridge[a], Christy Hoepting[b], and Frank Hay[a]
[a]Plant Pathology & Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell AgriTech at The New York Agricultural Experiment Station, Geneva, NY 14456; and [b]Cornell Cooperative Extension Regional Vegetable Program, Albion, NY 14411

Onion production is an important component of New York (NY) agriculture, producing approximately 145,000 US tons from 7,000 acres annually. Onion foliar health may be deleteriously affected by a complex of foliar diseases and disease management is critical to profitability. The main fungal, foliar diseases affecting onion in NY are: Botrytis leaf blight (caused by Botrytis squamosa), purple blotch (Alternaria porri), Stemphylium leaf blight (SLB, Stemphylium vesicarium), and downy mildew (Peronospora destructor). For many years, SLB has been of minor importance relative to other diseases in the complex, but has recently emerged as dominant and the primary driver of foliar health affecting broad-acre onion production in NY. The reduced green leaf area from SLB and other diseases deleteriously affects onion bulb size and by causing premature senescence of leaves.

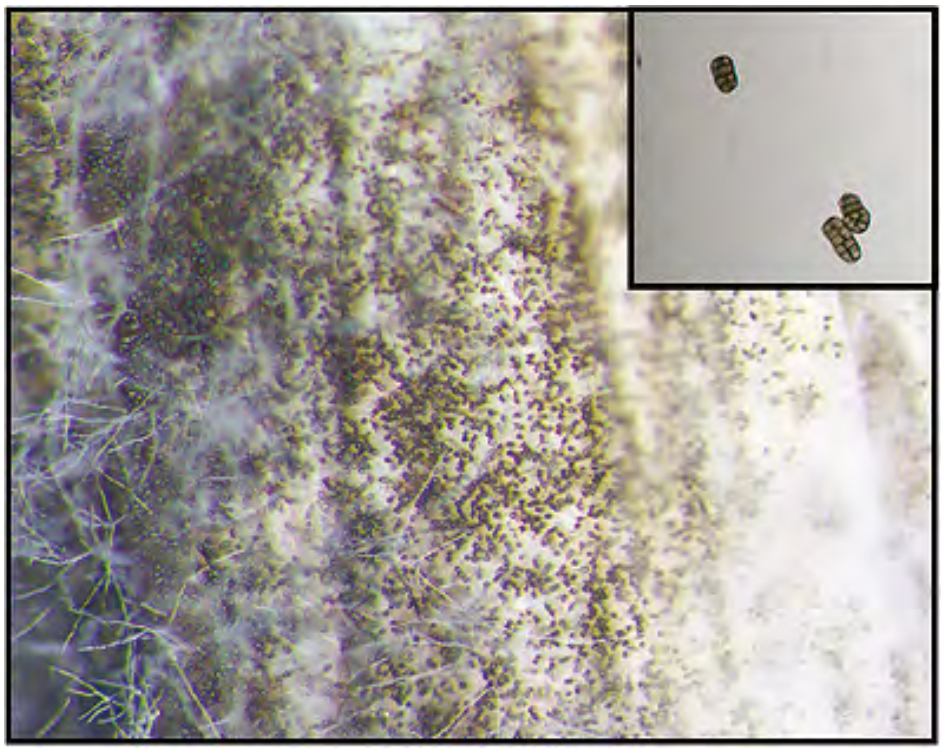
Symptoms. SLB lesions are initially small, tan to brown, and may be water-soaked, and progress to oval or circular in shape. The lesions turn light brown to tan in the center and become a dark greenish brown to black as they become older (Fig. 1A). The brown to black color is caused by the profuse production of asexual spores of the fungus, S. vesicarium (Fig. 2). In the latter part of the cropping season, the lesions often coalesce and rapidly progress and extend the length of the leaves, often progressing down one side of the leaf before the other (Fig. 1B).

Fig. 1. A, Symptoms of Stemphylium leaf blight (SLB) caused by the fungus, Stemphylium vesicarium progressing from a discrete lesion down the leaf; and **B**, older SLB lesions on a dead onion leaf.

Sarah Pethybridge is an Associate Professor and Program Leader (Plant Pathology) at Cornell AgriTech at The New York State Agricultural Experiment Station, Cornell University in Geneva, NY. 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 roles as an Extension Plant Pathologist at the University of Tasmania, Australia; and Science Group Leader (Field Crops) at the New Zealand Institute for Plant & Food Research. The focus of her program in New York is broadacre vegetables including table beet and leguminous crops (snap, lima and dry beans). She works collaboratively with Dr. Frank Hay (Senior Extension Associate) who is the primary investigator for diseases affecting onion and garlic

Lifecycle of S. vesicarium and inoculum sources. Our research is evaluating the means by which S. vesicarium is introduced into onion fields. The fungus has two spore stages: (i) conidia (Fig. 2) responsible for short-range dispersal within fields and the rapid increase in disease within the cropping season which are spread by wind and/or water splash; and (ii) ascospores that are likely to play a role in long-distance dispersal between fields. However, the role of ascospores in SLB initiation and spread in onion fields is relatively unknown. Infested onion leaf debris from a previous season may be an important source of inoculum for SLB epidemics. In our trials, burying and shredding onion leaf residue significantly reduced the incidence and severity of SLB in the subsequent season compared to leaving the residue on the soil surface intact or shredded. Rotation to non-hosts may also be an effective strategy to reduce overwintering inoculum by reducing green bridges, including alternative crop (e.g. other Allium crop species including garlic) or weedy hosts. In our research, S. vesicarium was found on necrotic lesions on selected broad-leaf weeds (field horsetail, Jimson weed, and pennycress) examined in field edges, and on sow thistle and volunteer onions within the field. In NY, little crop rotation in intensive production regions means there is little opportunity to reduce the initial inoculum of S. vesicarium and hence the risk of a SLB outbreak resulting in annual epidemics.

Fig. 2. Profuse production of Stemphylium vesicarium asexual spores (conidia; close-up in inset) on a Stemphylium leaf blight lesion on an onion leaf.



SLB control. Regular fungicide application for the control of foliar diseases is a standard component of broad-acre onion production. Efficacious products must coincide and act together to provide effective season-long disease control and adhere to the best management practices to prevent or manage fungicide resistance, and cost-effective returns. In NY onion fields, SLB spread is most rapid in late July and therefore timing of efficacious fungicides for disease control to coincide with this period may be optimal.

Our research has identified the development of resistance to single-site mode of action fungicides within the S. vesicarium population associated with SLB as a likely contributing factor in the emergence of this disease as dominant in the foliar disease complex affecting onion in NY. Of 105 S. vesicarium isolates collected from onion fields across NY tested for sensitivity to the strobilurin fungicide, azoxystrobin (Fungicide Resistance Action Committee [FRAC] group 11), 74 were resistant (70.5%). These isolates were also resistant to another strobilurin fungicide, pyraclostrobin. A sub-set of isolates were also tested for sensitivity to other fungicides registered for use in onion

in NY. Within FRAC group 7, a high proportion of Stemphylium vesicarium isolates were resistant to boscalid, but were sensitive to fluopyram and fluxapyroxad. Similarly a high proportion of isolates had moderate insensitivity to pyrimethanil and cyprodinil (FRAC group 9) while all were sensitive to iprodione (FRAC group 2), difenoconazole (FRAC group 3). The sensitivity of S. vesicarium isolates to active ingredient components in selected products registered for use in conventional onion production in NY is summarized in Table 1.

Table 1. Current status of sensitivity of Stemphylium vesicarium isolates to active ingredients within selected conventional fungicides registered for foliar disease control in onion in New York.

Product	**FRAC Group**				
	2	**3**	**7**	**9**	**11**
Quadris					Azoxystrobin (Resistant)
Quadris Top		Difenoconazole (Sensitive)			Azoxystrobin (Resistant)
Inspire Super		Difenoconazole (Sensitive)		Cyprodinil (Moderately sensitive)	
Rovral	Iprodione (Sensitive)				
(Sensitive)					
Luna Tranquility			Fluopyram (Sensitive)	Pyrimethanil (Moderately sensitive)	
Merivon			Fluxapyroxad (Sensitive)		Pyraclostrobin (Resistant)
Pristine			Boscalid Resistant)		Pyraclostrobin (Resistant)
Endura			Boscalid (Resistant)		
Scala				Pyrimethanil (Moderately sensitive)	

Ongoing research. Our research is aiming to enhance the sustainability of onion foliar disease management by evaluating the potential of forecasting to support fungicide application for SLB control. We are continually evaluating the status of fungicide resistance within the S. vesicarium population affecting onion focusing on FRAC groups 2 and 9, and reviewing fungicide resistance management guidelines.

Acknowledgments. We are grateful for funding from the NY Onion Research and Development Program, the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA) Hatch project NYG-625445, USDA-NIFA Federal Capacity project 2016-17-149, USDA-NIFA Specialty Crop Block project SCG 16-008 managed by the NY Farm Viability Institute, and USDA-NIFA Crop Protection and Pest Management Applied Research and Development Program (2016-70006-25838).

DEFEND YOURSELF AGAINST TICKS AND VECTOR-BORNE DISEASES

Karen C. Poh
004 Chemical Ecology Lab, Penn State University, University Park, PA 16802
kpp5400@psu.edu

As the number of tick-borne disease cases continues to rise, it becomes increasingly important to defend yourself against ticks and tick bites. Understanding the biology of ticks and their hosts will determine the best control and prevention methods against these blood-sucking arthropods.

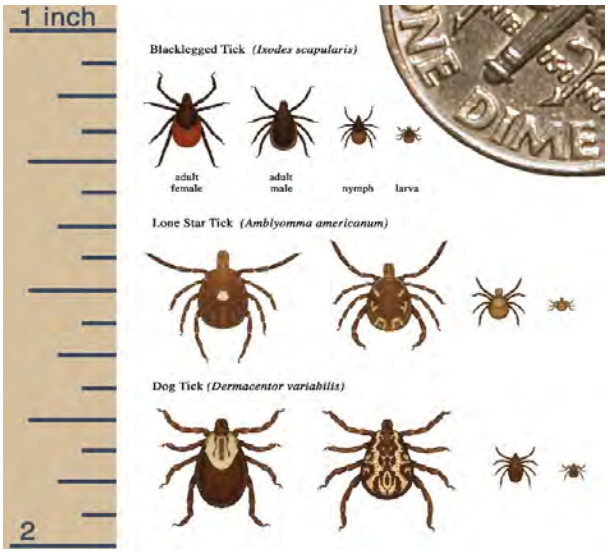


Figure 1. Summary of tick species. From the CDC.

Tick Biology

Ticks are everywhere across the United States, however, there are many different species and control and tick-borne disease risk will vary depending on the species. In the Mid-Atlantic, we are most likely to see the black-legged tick (BLT, Ixodes scapularis), but we may also encounter the lone star tick (LST, Amblyomma americanum) or the American dog tick (ADT, Dermacentor variabilis) (Figure 1). The sizes of these ticks will differ, depending on the species, sex, and life stage of the tick. In Figure 1, the BLT is the smallest tick compared to the LST and ADT. Females are generally larger than male ticks and can engorge or swell to several times their original size. To remember the tick life cycle, remember the "2-3-4" rule (Figure 2):

- 2-year life cycle
- 3-host tick (each feeding stage will require a different host)
  - * Larva: Birds and mice
  - * Nymphs: Mice and large mammals
  - * Adults: Large mammals
- 4 life stages (egg, larva, nymph, adult)

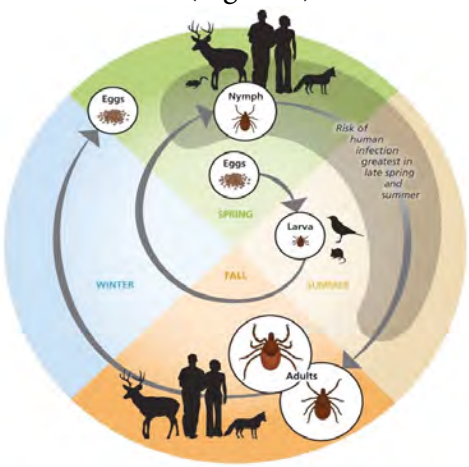


Figure 2. Tick life cycle. From the CDC.

The tick life stage of Ix. scapularis that is considered to infect most people and animals with Lyme disease or other tick-borne diseases is the nymphal stage. Nymphal Ix. scapularis can be as small as a poppy seed while adults can be as small as a sesame seed.

Lyme Disease

The types of pathogens transmitted by ticks will differ depending on the species of the tick. The most common tick-borne disease in the Mid-Atlantic is Lyme disease, which is is caused by a bacterium Borrelia burgdorferi. The BLT is the only tick known to transmit Lyme disease in the Mid-Atlantic. Lyme disease

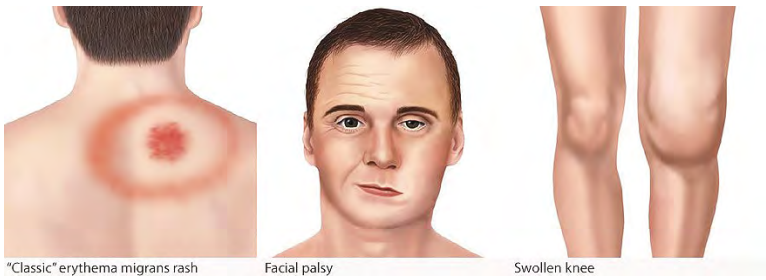


Figure 3. Symptoms of Lyme disease. From the CDC.

Karen Poh is a post-doctoral scholar in the Department of Entomology at Penn State University. As a native Texan, she received her BS in Public Health from the University of Texas at Austin, MPH in Environmental and Occupational Health Sciences from the University of North Texas Health Science Center School of Public Health, and her PhD in Entomology from Texas A&M University. Her research portfolio includes spatial modeling of mosquitoes, tick chemical ecology, establishing deer keds as pathogen vectors, and host-parasite associations.

has 2 stages. During the "early" phase, cases will exhibit flu-like symptoms and a bullseye rash may occur (Figure 3). However, about 30% of cases do not develop the bullseye rash. If Lyme disease is not treated during the early phase, then it may progress to the "late" phase. Cases that progress to the late phase may develop facial palsy, arthritis, joint swelling, or severe neurological symptoms. The period between the early and late phases will be different for every individual, ranging from weeks to years. If caught during the early phase, Lyme disease can be treated with antibiotics. During the late phase, many of the symptoms are permanent, but can be managed. It is important to visit your physician to get an official diagnosis if you have been outdoors, found a tick on yourself, feel flu-like symptoms, or a combination.

Defend Yourself: Control and Prevention of Ticks

With the increased risk for tick bites and tick-borne diseases in the Mid-Atlantic, it is vital to protect yourself. You may encounter ticks in many outdoor settings, such as hunting or hiking, but also in your typical daily life such as farming, gardening, or working in your yards surrounding your homes. To protect yourself, we recommend an "integrated pest management" (IPM) approach, which combines chemical, biological, mechanical/physical, and cultural methods.

To protect yourself while outdoors, consider following these suggestions:

- Wear light-colored clothing with long sleeves and long pants.s
- Tuck pants into your socks
- Apply DEET or similar EPA and CDC recommended repellent or treat clothing with 0.5% permethrin (Table 1)
- Conduct tick checks, put your clothes in the dryer (high for at least 45 minutes), and take a shower within 2 hours of coming back from the outdoors

Table 1. Recommended repellent options.

Active Ingredient	Type	EPA Registered?	Duration
DEET	Chemical	Yes	8-10+ hours
Picaridin	Chemical	Yes	Up to 8 hours
Oil of lemon eucalyptus	Synthesized plant oil	Yes	Up to 6 hours
IR3535	Synthesized plant oil	Yes	4-8 hours
Plant oils (soybean, lemongrass, cedar, citronella, etc.)	Nonsynthesized plant oil	No	Estimated 30 min. to 2 hours

Landscape and host-targeted control methods are also available. Landscape control includes eliminating tick habitats (leaf litter, tall grass, etc.) and eliminating tick host habitats (rock walls, log piles, etc.). Applying acaricides in the landscape is also an option, but there are limitations such as non-target effects, toxicity, and limited efficacy data on certain acaricides. Visit the EPA website (epa.gov) for guidelines on acarcide types and application instructions.

Figure 4. An example of a tick tube. From Thermacell.

Host-targeted control is aimed at treating white-footed mice (WFM, Peromyscus leucopus), a major host for larval and nymphal ticks and the main amplifying host for B. burgdorferi. Tick tubes are filled with cotton soaked in permethrin (Figure 4). WFM take the cotton and use it as nesting material in their burrows, thus treating and killing any ticks on themselves and any pups in the burrow. Bait boxes are small black boxes that contain bait material and a cotton wick coated in fipronil (Figure 5). As mice reach the bait, they will get treated with fipronil on their necks, which will kill ticks feeding on the mice. Some concerns using the tick tubes or bait boxes include permethrin leaching, placement accuracy, cost, and possible mice population increases.

IPM is a powerful tool that is customizable to your lifestyle and needs. We recommend a combination of all the methods listed here rather than relying on one type of method. With the risk of tick-borne diseases increasing throughout the Mid-Atlantic, the biology of ticks and their hosts are vital to understanding and choosing the best control and prevention methods.

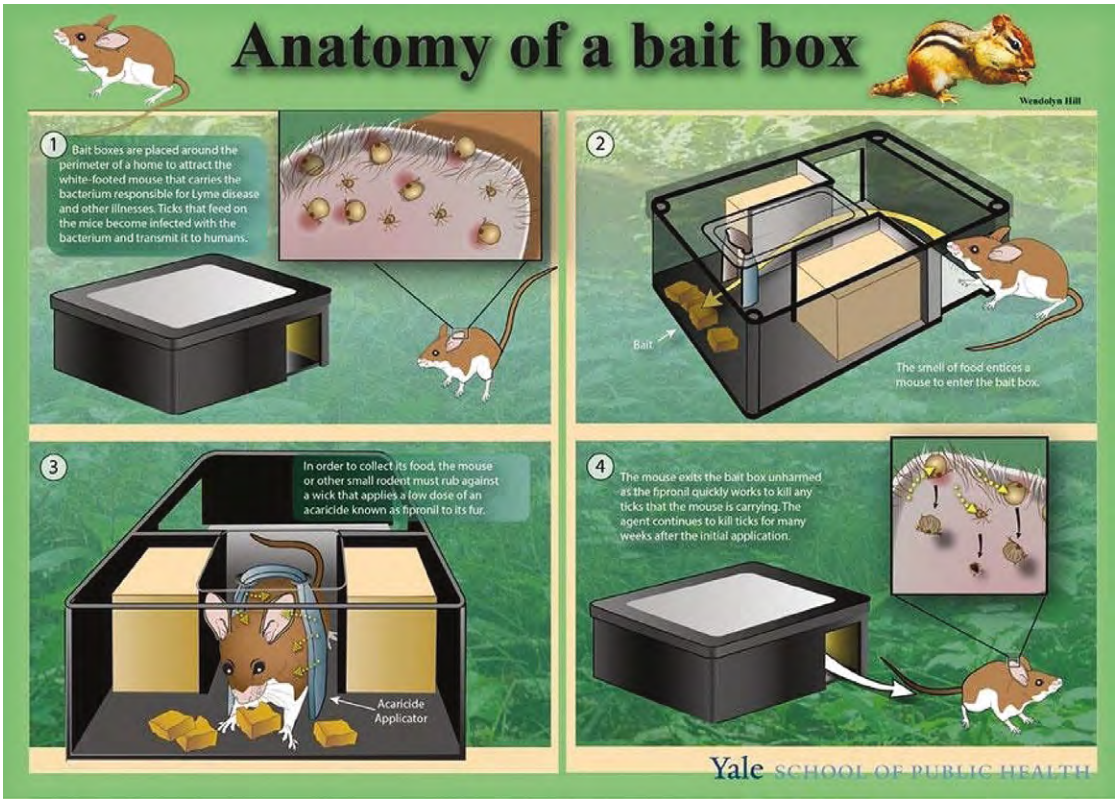


Figure 5. General layout of a bait box to treat wild mice. From Yale School of Public Health and Tick Control System.

SKIN CANCER: WHAT YOU NEED TO KNOW

Laura Toole
Northeast Regional Cancer Institute
334 Jefferson Avenue
Scranton PA, 18510
Laura.Toole@Scranton.edu

Doctors diagnose more than 3 million Americans with skin cancer each year, making it the most common type of cancer. If skin cancer is found early, it can usually be cured with topical medications, procedures done in the office by a dermatologist, or a relatively simple surgery. As a result, skin cancer is responsible for less than 1% of all cancer deaths. There are 4 main types of skin cancer:

Basal cell carcinoma. About 80% of skin cancers develop from this type of cell. Basal cell carcinoma most often develops on the head and neck, although it can be found anywhere on the skin. It is mainly caused by sun exposure. This type of skin cancer usually grows slowly and rarely spreads to other parts of the body.

Squamous cell carcinoma. Around 20% of skin cancers develop from squamous cells. Squamous cell carcinoma is mainly caused by sun exposure, so it may be diagnosed on many regions of the skin. It can also develop on skin that has been burned, damaged by chemicals, or exposed to x-rays. About 2% to 5% of squamous cell carcinomas spread to other parts of the body, which makes it more likely to spread than basal cell carcinoma.

Merkel cell cancer. Merkel cell cancer is a highly aggressive, or fast-growing, rare cancer. It starts in hormone-producing cells just beneath the skin and in the hair follicles. It is usually found in the head and neck region.

Melanoma. Melanocytes are cells that produce the pigment melanin, which gives skin its color. Melanoma starts in melanocytes, and it is the most serious type of skin cancer.

Risk Factors:

Sun exposure. Exposure to ultraviolet (UV) radiation from the sun plays a major role in the development of skin cancer. People who live at high altitudes or in areas with bright sunlight year-round have a higher risk of developing skin cancer. People who spend a lot of time outside during the midday hours also have a higher risk. Recreational suntanning should be avoided to reduce the risk of skin cancer.

Exposure to ultraviolet type B (UVB) radiation appears to be more closely linked with skin cancer, but newer research suggests that ultraviolet type A (UVA) may also play a role in the development. It is important to protect your skin from both UVA and UVB radiation.

Artificial tanning. People who use tanning beds, tanning parlors, or sun lamps have an increased risk of developing all types of skin cancer. There is no safe amount of indoor tanning.

Fair skin. People with a fair complexion, blond or red hair, blue eyes, and freckles are at increased risk for developing skin cancer. People whose skin has a tendency to burn rather than tan also have an increased risk. Despite this, all people, regardless of skin color, are at risk for developing skin cancer.

Precancerous skin conditions. Rough, red, or brown scaly patches on the skin, called actinic keratoses or Bowen›s disease, are usually more common in areas exposed to the sun. These areas can change into squamous cell cancers in a small number of people.

Gender. The number of older white men and younger white women who have developed skin cancer in recent years

Laura Toole is an oncology social worker who currently serves as the Executive Vice President of the Northeast Regional Cancer Institute in Scranton, PA. Ms. Toole works with an interdisciplinary team in the development, planning and implementation of cancer education programs and materials for cancer survivors and their families, healthcare professionals and the general public. In addition, Ms. Toole has worked for many years providing counseling and support services to oncology patients and family members. Ms. Toole has also made numerous local, state and national presentations on a variety of cancer-related topics. She is a Licensed Clinical Social Worker and received her Masters degrees in social work and law and social policy from Bryn Mawr College Graduate School of Social Work and Social Research.

has increased. Men are also more likely to develop Merkel cell cancer.

Age. Most basal cell and squamous cell carcinomas typically appear after age 50. However, in recent years, the number of skin cancers in people age 65 and older has increased dramatically, although this may be due to better screening and patient tracking efforts in skin cancer.

A history of sunburns or fragile skin. Skin that has been burned, sunburned, or injured from disease has a higher risk of skin cancer.

Previous skin cancer. People who have had any form of skin cancer have a higher risk of developing another skin cancer.

Inherited syndromes. Certain rare genetic conditions are associated with an increased risk of developing skin cancer.

Weakened or suppressed immune system. People with a weakened immune system due to a stem cell or a solid organ transplant or diseases such as HIV/AIDS and certain types of leukemia have a higher risk of developing skin cancer.

Medications. In addition to medications that suppress the immune system, certain steroids and medications that make the skin very sensitive to sunburns.

Previous treatment with radiation therapy. When a person receives radiation therapy as a cancer treatment, he or she has a higher risk of developing basal cell carcinoma. This risk increases over time, especially after 10 to 20 years. As a result, children who receive radiation therapy have a 6 times higher risk for developing a basal cell carcinoma.

Human papillomavirus (HPV). Research shows that this virus is a risk factor for squamous cell carcinoma, particularly if the person's immune system becomes suppressed. Sexual activity with someone who has HPV is the most common way someone gets HPV.

Prevention

Sun damage builds up over time, so it is important to take the following steps to reduce sun exposure and avoid sunburn:

- Limit or avoid direct exposure to the sun between 10:00 AM and 4:00 PM.
- Wear sun-protective clothing, including a wide-brimmed hat that shades the face, neck, and ears. Clothes made from fabric labeled with UV protection factor (UPF) may provide better protection. UV-protective sunglasses are also recommended.
- Use a broad-spectrum sunscreen throughout the year that protects against both UVA and UVB radiation and is SPF 30 or more. Reapply at least 1 ounce of sunscreen to your entire body every 2 hours or every hour after heavy sweating or being in the water.
- Avoid recreational sunbathing and do not use sun lamps, tanning beds, or tanning salons.
- Examine the skin regularly. This should include examinations by a health care professional and self-examinations.
- Early detection and recognition of skin cancer are very important. More than 75% of non-melanoma skin cancers/keratinocyte carcinomas are diagnosed by patients or their families. Recognizing the early warning signs of skin cancer and doing regular self-examinations of your skin can help find skin cancer early, when the disease is more likely to be cured. Self-examinations should be performed in front of a full-length mirror in a brightly lit room. It helps to have another person check the scalp and back of the neck.

Talk with your doctor if you find any of the following during self-examination:

For basal cell carcinoma, 2 or more of the following features may be present:

- An open sore that bleeds, oozes, or crusts and remains open for several weeks
- A reddish, raised patch or irritated area that may crust or itch, but rarely hurts

- A shiny pink, red, pearly white, or translucent bump
- A pink growth with an elevated border and crusted central indentation
- A scar-like, white, yellow, or waxy area, often with a poorly defined border

Squamous cell carcinoma can often crust, bleed, and appear as:

- A wart-like growth
- A persistent, scaly red patch with irregular borders that may bleed easily
- An open sore that persists for weeks
- A raised growth with a rough surface and a central depression

For **melanoma,** a simple way to remember the warning signs is to remember the A-B-C-D-Es of melanoma—

- "A" stands for asymmetrical. Does the mole or spot have an irregular shape with two parts that look very different?
- "B" stands for border. Is the border irregular or jagged?
- "C" is for color. Is the color uneven?
- "D" is for diameter. Is the mole or spot larger than the size of a pea?
- "E" is for evolving. Has the mole or spot changed during the past few weeks or months?

Source: CancerNet – www.cancer.net (Skin Cancer section)

FIXING WHAT WENT WRONG IN MY TOMATOES

Steve Bogash
NE Marrone Territorial Business Manager

Producing sustainable yields of high-quality tomatoes can be quite a challenge. There are so many variables that go into the final formula that dictate yield and quality that require constant juggling.

Cracking is largely caused by water imbalances and skin weaknesses. A solid nutrition plus irrigation program that is regularly monitored and adjusted will greatly reduce cracking. Special attention needs to be directed at calcium (Ca) tissue levels beginning at fruit set. This is both the actual Ca tissue level and where that level is in relation to other nutrients. Newer products such as Haven™ and Bluestim™ increase transpiration so should help in moving Ca from the soil solution to plant sinks. These products must be used proactively as they will not help to heal existing cracks.

Yellow Shoulder is caused by insufficient potassium(K) in developing fruit at the time of fruit set. Producing a yellow shoulder free tomato crop requires a lot of potassium with an acre requiring #200 or more of available K. Soil solution pH needs to be between 6.2 and 6.5 in order to make sure that K is available. Hydroponic systems may require a slightly lower pH. The balance between tissue K levels and other nutrients has a major impact on available K with too high Mg, Ca or N having the greatest impact. Tissue testing and nutrition adjustment must begin prior to flower bud initiation in order to prevent yellow shoulders.

Zippering is caused by excessive humidity at fruit set. The high humidity causes pollen grains to be extra 'sticky'. Zippering is generally not a huge issue, but increasing ventilation should reduce this problem.

Blossom End Rot (BER) is caused by insufficient Ca in developing fruit at fruit set and shortly thereafter. This can be caused by excessive levels of other nutrients but is most often the result of low transpiration levels as BER damaged fruit are setting. Thus, we often see BER in high tunnels and greenhouses early and late in the season when light levels are low and we get multi-day cloudy weather events. Careful attention to irrigation coupled with the use of chelated Ca applied to foliage and foliar applications of Haven™ and Bluestim™ should reduce BER to acceptable levels. While the blossom end is most often where we see the damage it can occur anywhere on the developing fruit.

Poor Fruit Set can be caused by many things on the following partial list: poor pollination, over-pollination, low P levels, low K levels, micronutrient deficiency and toxicity (too low and too high), excessive N levels, high Western Flower Thrips populations, , insufficient light levels, botrytis damage to flowers, and many more plant stressors.

P deficiency in older plants is often expressed as poor overall growth with a an overall 'grayish' appearance. At extremely low levels tomato plants will simply shut down and growth will cease. Purpling of the stems may be seen at these low levels but is more likely to be seen on seedlings that are being held longer than desired due to delayed planting. Purpling in seedlings will rapidly diminish once that are transplanted and they have access to nutrients. Withholding P while plants are in transplant trays is a good practice to manage height in plants being held. Low P levels can result on poor fruit set.

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

K deficiency will result in poor fruit set, the failure for plants to continue to develop flowers and yellow shoulders. As levels drop fruit quality and flavor will suffer as K is largely responsible for moving sugars from leaves into fruit. Tomatoes are 'luxury' consumers of K, so will benefit from excess. The application of K to foliage acts synergistically with root applications to promote overall tissue K levels.

Mg Deficiency is most often seen as blotchy leaves. Low levels of Mg can result in poor fruit set and BER. Mg is very important in the development of chlorophyll, so plants with low levels appear blotchy and yellowed. While MgSO4 (Epsom salts) is an excellent source of Mg when applied to the soil, when solving low tissue levels using a chelated Mg along with or without MgSO4 will work substantially faster.

Botrytis is most commonly seen as gray fuzz on stems and flowers under high humidity conditions, but it can also be seen on fruit as scattered target spots where spores have germinated. Improving ventilation and reducing humidity is the best way to reduce botrytis levels. The application of PAA materials such as Jet-Ag™ and Oxidate™ will oxidize surface spores and mycelia reducing inoculum levels. During cool, cloudy, rainy weather, these applications may need to be done daily. While PAA applications do an excellent job of reducing inoculum they leave no residue behind, so longer acting botryticides such as Stargus, BotryStop™ and other contact materials may be required.

IDENTIFICATION AND MANAGEMENT OF FOLIAR DISEASES OF TABLE BEETS

Sarah Pethybridge[a] and Julie Kikkert[b]
[a]Plant Pathology & Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell AgriTech at The New York Agricultural Experiment Station, Geneva, NY 14456; and [b]Cornell Cooperative Extension Regional Vegetable Program, Canandaigua, NY 14424

Demand for table beets is exponentially increasing with popularity linked to enhanced consumer awareness of the health benefits of consumption. In New York (NY), table beet production ranges from broad-acre to small, diversified farms, and either system may be conventional or organic. The primary foliar diseases affecting table beet are (i) Bacterial leaf spot (BLS) caused by Pseudomonas syringae pv. aptata; (ii) Cercospora leaf spot (CLS) caused by the fungus, Cercospora beticola; and (iii) Phoma leaf spot (PLS) caused by the fungus, Phoma betae. Alternaria leaf spot is another fungal disease of emerging importance. For the fresh market, low levels of disease may lead to rejection due to poor quality foliage and roots. In broadacre production, harvesting of table beet is often by top-pulling machinery, which relies upon healthy foliage to remove roots. Healthy foliage is therefore critically important to table beet production irrespective of production system.

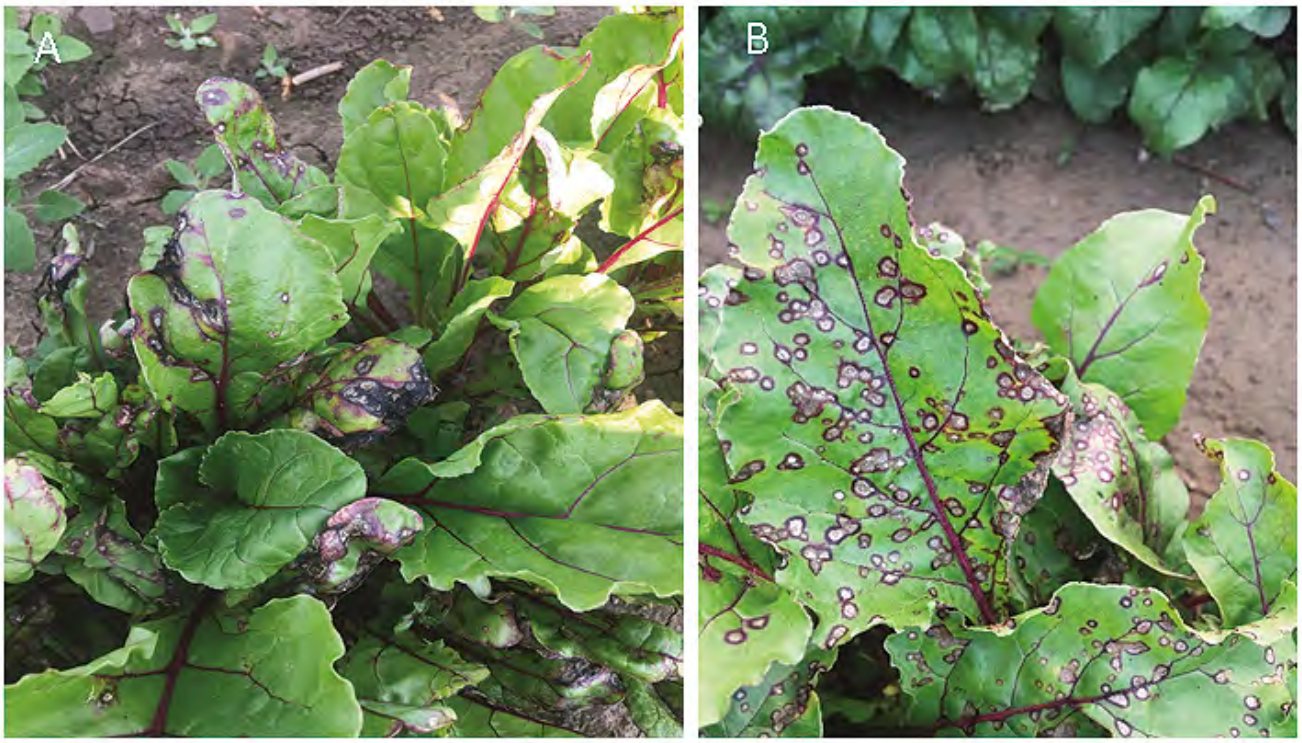
Bacterial leaf spot (BLS). BLS of table beet is caused by the bacterium, Pseudomonas syringae pv. aptata. The disease often occurs early in the season when conditions are wet and cool (50 to 60°C) and typically first in small clusters. Coincidentally, the disease is most severe when plants are young and establishing (up to 6 to 8 true leaves). However, it is unknown whether this is due to enhanced susceptibility when plants are less mature or exposure to more conducive conditions for infection and disease development. Symptoms of BLS are black to gray in color and closely resemble CLS, but do not contain black, pin-head size fungal structures (see CLS and PLS descriptions below). Affected leaves also appear malformed and distorted around the lesions (Fig. 1A). The pathogen may be seedborne and sourcing certified seed (organic or conventional) is critically important for disease management. However, the pathogen may also survive in the soil, on infested crop residue, and in irrigation water. Swiss chard is also susceptible to BLS (and other diseases affecting table beet) and therefore rotation between crops in the 'beet family' of at least three years is recommended. Application of copper-based formulations is the only control tactic effective for BLS, however, the impact of the disease usually becomes less in warmer, drier weather. No information is available on the susceptibility of popular table beet cultivars to BLS.

Cercospora leaf spot (CLS). CLS is caused by the fungus, Cercospora beticola. The fungus also causes disease on vegetables within the 'table beet family', including spinach and Swiss chard. The means by which the pathogen spreads between fields is largely unknown, however it is likely to survive between seasons on infected plant debris as a mass of thickened mycelia that produce asexual spores called conidia. These spores are disseminated through wind and rain splash to infect table beet foliage. Symptoms of CLS begin as small gray spots on the leaves (Fig. 1B) and petioles that coalesce under conducive environmental conditions and result in defoliation. In a red table beet cultivar, CLS lesions have a red to purple margin (Fig. 1B), but in yellow and white cultivars, the margin is tan to brown. CLS symptoms may be distinguished from other lesions by the presence of the thickened mycelial mass that gives rise to conidia (pseudostromata) observed with a hand lens as tiny black, pin-point structures. CLS does not directly affect table beet roots but disease symptoms can reduce the amount of foliage produced by plants and hence

Sarah Pethybridge is an Associate Professor and Program Leader (Plant Pathology) at Cornell AgriTech at The New York State Agricultural Experiment Station, Cornell University in Geneva, NY. 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 roles as an Extension Plant Pathologist at the University of Tasmania, Australia; and Science Group Leader (Field Crops) at the New Zealand Institute for Plant & Food Research. The focus of her program in New York is broadacre, processing vegetables including table beet and leguminous crops (snap, lima and dry beans).

the carbohydrates available for root sizing and production.

Fig. 1. A, Bacterial leaf spot caused by Pseudomonas syringae pv. aptata; and B, Cercospora leaf spot caused by the fungus, Cercospora beticola.



In the field, CLS usually begins as small, randomly distributed areas of affected plants, which spread rapidly under conducive conditions (elevated relative humidity and temperatures between 75 to 80°F). For this reason, CLS is generally more prevalent in the middle and later stages of crop development in summer.

Regular application of synthetic fungicides is a central part of within-season CLS control in conventional table beet production. However, as the C. beticola population is very diverse it has the ability to rapidly develop resistance to single-site mode of action fungicides. For example, in C. beticola populations in NY, up to 75% of isolates are resistant to the strobilurin fungicide, azoxystrobin (Fungicide Resistance Action Committee Group [FRAC] 11). However, strobilurin fungicides remain an important component of disease management in table beet as they are currently the sole product available for early season pocket rot and root disease control caused by the soilborne fungus, Rhizoctonia solani. Approximately 30% of C. beticola isolates are also moderately resistant, and some (~ 1%) highly resistant to demethylation inhibitor fungicides, such as propiconazole (FRAC 3). In our trials, pre-mixed formulations containing active ingredients belonging to FRAC group 7 have provided superior CLS control and as a result, Miravis Prime (Syngenta) is expected to be available for use on table beet in NY in 2020.

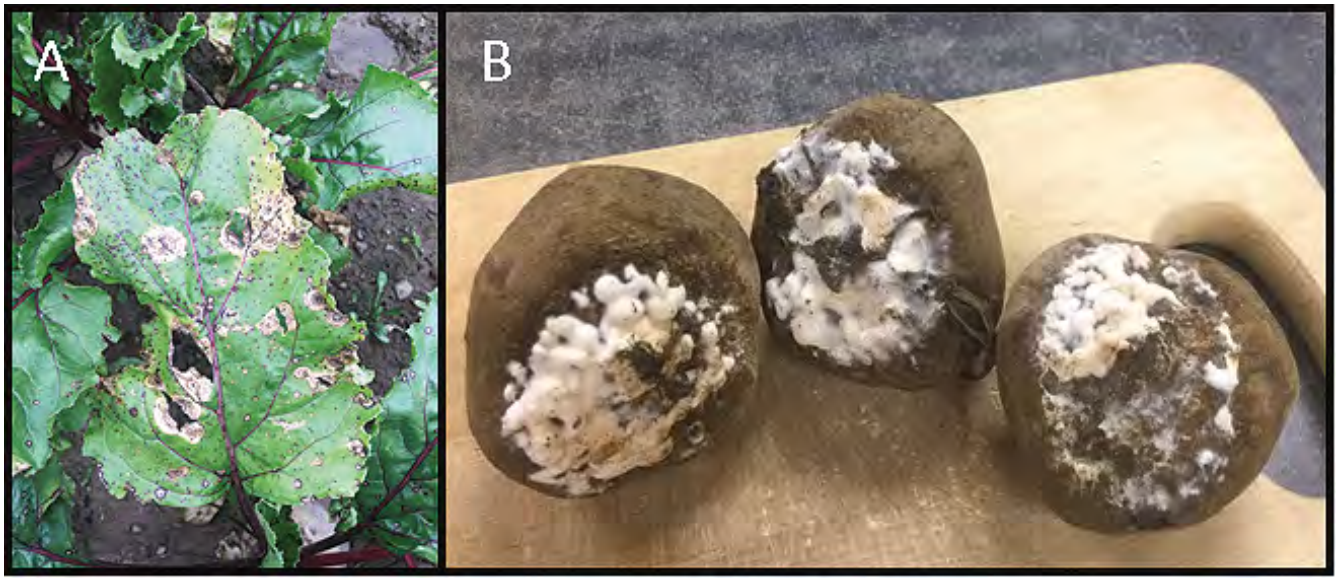
For organic table beet production, OMRI-listed copper formulations provide moderate control of CLS when applied regularly throughout the season. However, copper accumulation in the soil and the potential for phytotoxicity when applied at high temperatures means other efficacious products are desirable. Of the OMRI-listed products tested in NY, Double Nickel (FRAC 44) and LifeGard (FRAC P06) have also provided moderate control and in many cases, not significantly different from azoxystrobin or copper-based products. This finding emphasizes the utility of these products in both conventional and organic table beet production with major benefits for fungicide resistance management.

Our research is aiming to improve CLS control by integrating epidemiological information to better inform disease risk for judicious fungicide scheduling. We have integrated the predictive model used to underpin a forecasting system for CLS in sugar beet in North Dakota into the North East Regional Climate Center's Network for Environment and Weather Application (newa.cornell.edu). The model uses temperature and relative humidity data collected at the standard height of 5-ft.

Applying fungicides according to risk thresholds predicted by the forecasting system have provided adequate CLS control and reduced the number of sprays compared to calendar-based applications. This forecasting system will soon be available through NEWA-linked weather stations along with supporting materials and documentation.

Phoma leaf spot (PLS). PLS is caused by the fungus, P. betae. PLS symptoms are tan to brown in color, circular and can spread across veins, and often crack and tear through the center of the lesion (Fig. 2A). Dark, concentric rings of black fungal structures called pycnidia that contain the spores of P. betae are usually obvious within the lesions without a hand lens. Spores ooze out of the pycnidia when leaves are wet and are disseminated short distances by rain splash. Unlike BLS and CLS, P. betae is also a significant pathogen of table beet roots and foliar disease symptoms may hence represent a risk for spread into the center of the crown causing a black to brown rot usually through the top and down the central core. If the infected roots (even when they appear healthy) are placed in storage, the rot rapidly advances into post-harvest decay and often accompanied by white, dense fungal mycelia around the center of the crown (Fig. 2B). The pathogen may be spread by infested seed but is also soilborne, and either source of inoculum may also be responsible for reductions in crop stands through damping-off. The selection of certified seed is therefore a critical step in preventing pathogen introduction. The use of synthetic fungicides applied as a seed treatment (e.g. thiram) is most likely the single most important factor contributing to the low prevalence and incidence of this disease in conventional table beet production. Nontreated seed therefore represents a potential source of inoculum for P. betae for organic table beet fields. Non-red cultivars (Avalanche, Boldor and Chioggia Guardsmark) are less susceptible to PLS than selected red cultivars (Falcon, Merlin, Rhonda, Red Ace, and Ruby Queen) which are all equally susceptible.

Fig. 2. A, Phoma leaf spot and **B**, root rot symptoms caused by the fungus, Phoma betae on table beet.



Acknowledgments. We are grateful for funding from the NY Vegetable Research Association and Council, the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA) Hatch project NYG-625424, USDA-NIFA Specialty Crop Block project SCG 18 001 managed by the NY Farm Viability Institute, and USDA-NIFA Crop Protection and Pest Management Applied Research and Development Program project number 2016-07645

BASIC POST HARVEST TECHNIQUES FOR VEGETABLES

Penelope Perkins-Veazie
North Carolina State University, Plants for Human Health Institute, Department of Horticultural Science
600 Laureate Way, Kannapolis NC 28081
Penelope_perkins@ncsu.edu

Vegetables encompass different plant parts, from roots and tubers to stems, leaves, flowers, fruit and seeds. Generally, roots and tubers have the best storage life while leaves, flowers, and seeds are most vulnerable to loss of quality. The range of techniques used for precooling and storage can be quite simple curing and storing protocols to more management-intensive vacuum cooling systems. Since plants continue to breathe after harvest, they use water and produce heat as part of respiration. Slowing respiration and water loss greatly helps vegetable quality and shelf life.

Having an idea of market options before the season is important so that appropriate cooling and storage facilities can be arranged. Consider what varieties might better suit harvest windows and markets, and make sure field nutrition and irrigation are well managed for good but not excessively lush growth. Harvest at the correct maturity for the crop and the market, and keep injured or decayed product separate from marketable product. Some vegetables can be harvested and field packed, followed by heat removal at the packing shed. With most vegetables, harvesting in the cooler part of the day, as soon as dew dries, helps with quality and reduces the field heat that will need to be removed later. Some great tips on ways pre-harvest changes in irrigation can affect ease of harvest, flavor and quality can be found at https://www.storeitcold.com/post-harvest-vegetable-care-on-the-farm/.

Types of cooling systems

Pre-cooling can range from room or forced air cooling to use of water, ice, or pressure changes such as hydro cooling or vacuum cooling. The choice of cooling system depends on the crop, the amount of field heat present, and the size of the load to be cooled. Forced air cooling systems for small loads can be made simply (see http://rvpadmin.cce.cornell.edu/uploads/doc_101.pdf). Hydro cooling or spray washing can be done on a small scale with a hose and bucket or with commercial systems. Once field heat is removed, the vegetable should be placed in coolers at the storage temperature and humidity that best suits it.

Coolers

Cold rooms can be purchased pre made or adapted from shipping containers or built from scratch. The classic cold room is similar to that used by restaurants, but should have a larger evaporative capacity to keep relative humidity higher (near 80%). Also, place a cooler under some sort of protective shelter. This cuts down on solar radiation and makes it easier for the cold room to keep up with cooling demands. Many growers have started using the cool bot technology, which essentially fools a digital AC unit into putting out cold air to temperatures well below the usual 60 °F cut off (see https://www.storeitcold.com). Loan programs may be available for cold rooms through USDA programs (see resources section). Guides for determining the choices of coolers and refrigeration needs can be found at CEFS https://www.ncgrowingtogether.org/for-producers/ and USDA handbook 66 https://www.ars.usda.gov/ARSUserFiles/oc/np/CommercialStorage/CommercialStorage.pdf

Quality loss in many vegetables is first seen as shrivel, wilt, softening, or loss of crispness. This is symptomatic of

Penelope Perkins-Veazie is a research professor in horticulture at the Plants for Human Health Institute at the North Carolina research campus in Kannapolis NC. She works with storage technologies, shelf life extension, and phytochemicals in fresh fruits and vegetables. Dr. Perkins-Veazie is a native of Maine and has a B.S. in plant and soil sciences from the University of Maine at Orono with a M.S. and PhD in horticulture from the University of Florida. Dr. Perkins-Veazie worked for USDA-ARS as a Postharvest Plant Physiologist in Lane, Oklahoma prior to joining the NCSU faculty.

water loss. Other changes include yellowing, which is often from ethylene action, sunken lesions and mold, which can be from storage at too low a temperature (chilling). Best storage temperatures are often related to the origin of the crop, such as tropical or temperate. Also, vegetables harvested at immature stages, when growth is rapid, are much more prone to water loss and rapid quality changes than when harvested at more mature stages. Charts that provide best temperatures for specific vegetables and recommendations for ethylene sensitive crops can be found at www.pma.com.

The UC Davis system divides produce into three temperature zones for short term storage (Thompson et al., 1996 at: http://postharvest.ucdavis.edu/Commodity_Resources/Storage_Recommendations/Compatibility_Chart_for_Short-term_Transport_or_Storage/index.cfm). This system is designed for a 7 day storage period. The leafy greens, sweet corn, green peas, cole crops, cantaloupe, broccoli, asparagus, and root crops like carrot, radish, and turnip fall into group 1, with recommended storage at 32 to 36 °F and 90 to 98% relative humidity. Fruiting type crops such as tomato, bell pepper, okra, cucumber, southern pea, summer squash are in group 2 at 45 to 50 °F and 85 to 95% RH. Group 3 includes winter squashes, pumpkins, watermelon, ginger, onion, tomato, potato, sweet potatoes and are stored warmest at 55-65° F and 85-95% RH.

One of the challenges frequently encountered is partitioning cooler space for produce with different temperature needs. Sometimes this can be dealt with by having a harvest gap between cold temperature and warm temperature crops. Another approach is to place the warmer temperature produce near the door and colder temperature produce at the back of the cooler nearer the fans. Each time the cooler door is opened, air temperatures will rise a few degrees near the door. This approach will be more successful with produce that has less than a 10 °F difference in best storage temperatures.

Resources

Many resources can be found on line for postharvest guidance, including extension and government publications, and also some commercial sites/blogs. Besides those mentioned above, others include:

NC State Extension publications (postharvest)
https://content.ces.ncsu.edu
Storage guidelines for fruits and vegetables (Cornell) http://chemung.cce.cornell.edu/resources/storage-guidelines-for-fruits-vegetables.pdf

UC Davis postharvest fact sheets
http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/
The Produce Nerd https://www.theproducenerd.com/

USDA REAP program for energy efficient cooler funding/loans https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency

USDA-FSA (Farm Service Agency): makes loans and microloans for cooling, cold trucks. See: https://www.fsa.usda.gov/programs-and-services/price-support/facility-loans/farm-storage/

ARE FARMERS MAKING ANY MONEY?

Franklin Egan
PA Association for Sustainable Ag (PASA)

The National Agricultural Statistics Service (2015) estimates that direct market farm sales are a $439 million per year industry in Pennsylvania, with much of this business coming from diversified vegetable farms. Yet little information is available to help diversified vegetable farmers understand how their businesses compare to their peers and industry-wide trends.

Over the past two years, PASA has been working with 41 farmers across Pennsylvania, Maryland, and West Virginia to collect farm financial data that describes the range of typical and possible business outcomes for diversified, direct-market vegetable farms. Our data show that for 2017: the median gross revenue from vegetables was 22,740 per acre; the median net income from vegetables was $12,416; and the median farm business income (including a range of other enterprises) was $37,253. Although some farms lost money in 2017, our data also show some examples of farms with incomes at least 5x greater than the median value. These data point to several strategies for higher farm incomes, including expanding production scale, maximizing revenues per acre, or diversifying into other farm enterprises.

Farms participating in this study receive a detailed financial report and are invited to participate in peer-to-peer discussions to share strategies for business success. PASA will be holding multiple workshops and webinars for new farms to participate in this project in 2020.

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

INDUSTRIAL HEMP IPM

Kadie E. Britt and Thomas P. Kuhar
Department of Entomology, Virginia Tech
220 Price Hall, 170 Drillfield Drive, Blacksburg, VA 24061,
kadieb@vt.edu

Many insects are present in indoor and outdoor hemp throughout Virginia and it is important to determine which species potentially pose a threat to successful production and yield. Since 2017, research efforts have been focused on addressing insect pest management concerns for growers in Virginia and beyond. Several generalist insects are present in fields, including Japanese beetle (Popilia japonica), a complex of stink bugs (brown marmorated stink bug, Halyomorpha halys; brown stink bug, Euschistus servus; and green stink bug, Chinavia hilare), and corn earworm (Helicoverpa zea), which has proven to be the most damaging pest for outdoor hemp production in Virginia. There are also a couple of specialist arthropods found on hemp outside and indoors, including the cannabis aphid (Phorodon cannabis) and hemp russet mite (Aculops cannabicola). Ongoing research in Virginia has revealed that defoliation (or loss of leaf area) of hemp will likely not negatively affect yield and is not to be a great concern for growers. Additionally, our research has shown that stink bugs, although damaging to other crops, do not appear to be a concern for yield or quality loss in hemp, at least at this time.

Chewing insects such as caterpillars, beetles, and grasshoppers are sometimes present in heavy densities on hemp plants and can often consume a substantial amount of foliar material. Very little is known about the impact of insect herbivory on hemp. In 2018 and 2019, an experiment was conducted to simulate insect defoliation on grain variety hemp plants ('Felina 32,' dual-purpose grain/fiber variety) to determine whether a loss of foliar area could impact yield. This experiment was conducted at Virginia Tech's Kentland Research Farm in Whitethorne, VA. All leaves on all hemp plants within research plots were manually defoliated with shears to remove varying levels of foliar material at varying times throughout the season. Plants were defoliated at 20, 40, and 60 days post planting (to simulate early, mid, and late season insect infestations) at levels of 0%, 25%, 50%, and 75% (to simulate damage at no, low, medium, and high levels of insect infestation). 'Felina 32' variety hemp plants typically have an approximate 90-day growing period in the field. Seeding rate both years was 30 pounds of seed per acre. Planting dates for this study were 8 June 2018 and 30 May 2019. The results from both years of this experiment showed that average seed weight per hemp plant was not significantly affected by timing or amount of foliar area removed from plants. These results support the belief that hemp is an extremely durable and injury-tolerant crop. It is possible that actual insect feeding injury rather than manual defoliation using shears could potentially elicit a different plant response. However, similar experimental methods have been applied in many other crop systems (garlic, onion, corn, sunflower, cowpea) using manual defoliation and results from these studies significantly negatively affected plant yield. Lastly, although this experiment revealed that grain yield was not affected, it does not provide any information as to whether chemical production of THC (tetrahydrocannabinol) or CBD (cannabidiol) is altered. Future directions will

Kadie Britt is a 3rd year PhD student in the Department of Entomology at Virginia Tech working with Dr. Thomas Kuhar, Virginia vegetable entomology specialist. Her doctoral research is focused on insect pest management in hemp. Kadie has worked with growers and Extension agents in Virginia and beyond to learn about and help alleviate the issues faced by those growing hemp in field or indoor environments. Prior to arriving at Virginia Tech, Kadie earned her Master's degree in Entomology from the University of Tennessee in Knoxville. She also has a Bachelor of Science degree in Environmental Studies from Emory & Henry College in Emory, VA. She is originally from Marshville, NC.

Tom Kuhar is a Professor and Vegetable IPM Specialist 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 insect pests of potato and vegetable crops. He has trained over 20 graduate students and has published over 120 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

explore potential chemical content alteration within grain and CBD variety hemp plants.

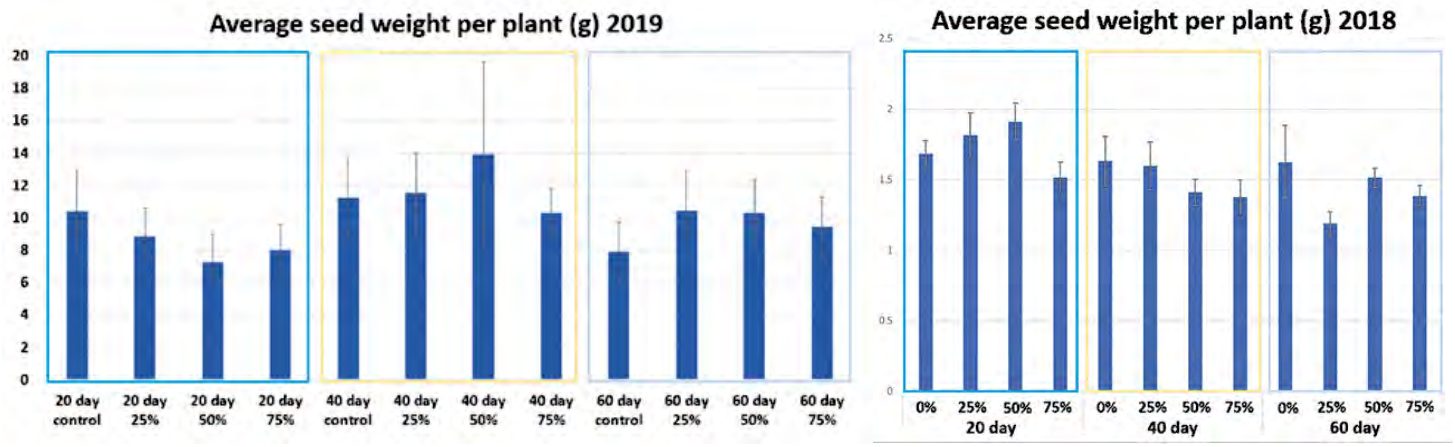


Fig. 1. Seed weight yield per plant of grain hemp 'Felina-32' after four manual defoliation levels at three different times after crop development. Experiment conducted in Whitethorne, VA.

Since corn earworm is the most damaging pest of outdoor grown hemp at this time, research efforts have largely focused on management options for this insect. Corn earworm feeding can lead to reduced yield and quality of hemp; feeding wounds on plants can allow for greater incidence of bud rot, caused by opportunistic invasion of Botrytis cinerea, or grey mold. Lab and field assays have shown promising results for the insecticide Entrust (active ingredient Spinosad), although this product is currently not allowed for use on hemp in Virginia or other states due to legal restrictions. Certain other insecticides with the active ingredient Bacillus thuringiensis (Bt) (trade names Javelin, DiPel, XenTari, Agree, Deliver) are allowed for use on hemp in Virginia. Products with Bacillus thuringiensis var. kurstaki have shown lower efficacy against corn earworm, while at least one product with two Bt strains (kurstaki and aizawai) has shown greater efficacy in our studies (up to 75% mortality in a lab assay).

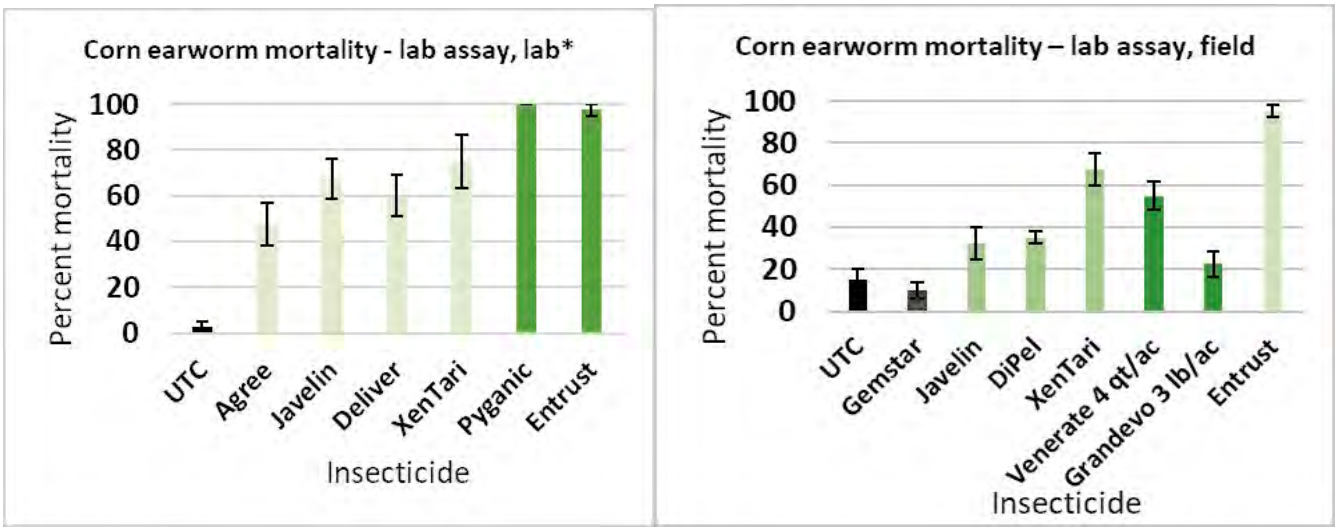


Fig. 2. Mortality of corn earworm larvae placed on hemp seed heads treated with different insecticides. Note, Entrust is not labeled for use on hemp in Virginia

Another pest that is highly difficult to manage is the hemp russet mite. Once physical symptoms of hemp russet mite feeding injury are observed, a heavy population density already exists. Mite presence can only be documented via the use of high-power microscopy (15x magnification or greater). Hemp russet mite is a greater problem in indoor growing environments since it is near impossible to eradicate once populations have established. In November 2019, we evaluated several natural and conventional miticides (Table 1) in order to control hemp russet mite populations on CBD-hemp

plants in an indoor growing facility.

Table 1. Miticide treatments that were evaluated on hemp russet mite in Virginia.

Product (manufacturer)	Active ingredient
Grandevo (Marrone Bioinnovations)	30% Chromobacterium subtsugae strain PRAA4-11 and spent fermentation media
Venerate (Marrone Bioinnovations)	94.5% Heat-killed Burkholderia spp. strain A396 cells and spent fermentation media
Sulfur (Bonide)	90% Sulfur
Requiem EC (Bayer Crop Science)	16.8% Plant extract of Chenopodium ambrosioides
M-Pede (Gowan Corp.)	49% Potassium salts of fatty acids
PLP (PLP Natural Products, Inc.)	Mix of natural oils, citronella 3.2%, lemongrass 3.8%, peppermint 3.2%, cinnamon 3.7%, and garlic 3.8%
Mammoth (Mammoth Products)	Thyme oil
Agrimek SC (Syngenta Crop Protection)	8% abamectin
Movento (Bayer Crop Science)	22.4% spirotetramat
SuffOil-X (Arbico Organics)	highly refined, pre-emulsified mineral oil

There was no significant treatment effect on counts of russet mites at 6 DAT or 10 DAT (Table 2), but by 25 DAT (Dec 3), there was a significant treatment effect with the untreated control and Grandevo treatments having the most mites, and several of the treatments having significantly fewer mites than the untreated control including: PLP Natural, Mammoth, Agrimek, Movento, SuffOil-X, Venerate, Sulfur, and Requiem EC.

Table 2. Hemp russet mite densities on excised hemp leaves from indoor CBD hemp plants treated twice with various natural and synthetic miticides at maximum labeled rates, Hillsville, VA, 2019†

		Hemp russet mites per 1 cm2 at 3 sample dates post spraying		
Treatment*	**Rate per gallon**	**14 Nov (6 DAT)**	**18 Nov (10 DAT)**	**3 Dec (25 DAT)**
Untreated control		120.5	39.3	57.5 ab
Grandevo	0.48 oz	57.8	24.8	65.5 a
Venerate	0.96 fl oz	55.8	36.8	26.5 cd
Sulfur	3 tbsp	58.3	25.5	12.5 cd
Requiem EC	0.96 fl oz	73.5	18.3	15.0 cd
M-Pede	0.315 fl oz	72.5	33.5	37.5 bc
PLP Natural	3.2 fl oz	33.8	6.5	10.5 d
Mammoth	3 fl oz	47.0	21.3	6.8 d
Agrimek	0.0425 fl oz	53.8	8.5	8.5 d
Movento	0.09 fl oz	74.3	15.0	5.8 d
SuffOil-X	2.56 fl oz	93.0	13.8	8.0 d
P-vaue		NS	NS	0.001

*Treatments were applied on two dates, 6 and 8 November, 2019; †Ten hemp leaves were collected per plot and a mite brushing machine was used to assess mite populations under magnification.

Moving forward, it will continue to be a challenge to manage insect pests in hemp due to legal restrictions surrounding pesticide use in the crop. Studies in Virginia will continue to address integrated solutions for insect pest management in hemp.

ASPARAGUS PRODUCTION TIPS

Thomas G. Ford
Penn State Extension
401 Candlelight Drive, Suite 220, Ebensburg, PA 15931
Email: tgf2@psu.edu

Asparagus acreage in the United States continues to decline due to the rise of foreign imports in the market. Big box stores and grocery chains are sourcing over 91.2% of their fresh grown asparagus from Peru or Mexico (2015) compared to only 10.8% of the fresh market asparagus being sourced from abroad in 1980. While the decline in U.S. asparagus production has been quite precipitous the emergence of buy local and sustainable sourcing initiatives may provide a glimmer of hope to small growers located near population centers along the East Coast.

U.S. asparagus consumption grew to 1.5 pounds per person per capita (2015) from 0.8 pounds per capita in 1980. In comparison almost 3.7 pounds of asparagus are consumed per capita in Germany (2017). An increase in US per capita consumption could be achieved if an effective marketing campaign could be initiated that emphasized the nutritional benefits of asparagus in human diets.

Asparagus is a long-lived herbaceous perennial that can be grown successfully in the same location for 20 years or more. Asparagus plants are considered dioecious which means that male and female reproductive structures are observed on different plants. The selection and planting of male clones has led to higher yields (50% more) while eliminating volunteer asparagus seedlings from germinating within the asparagus planting.

Asparagus Cultivars

The Mid-Atlantic Commercial Vegetable Guide recommends that the following asparagus cultivars be planted in the Mid-Atlantic region. While there may be other cultivars that are sold in the Mid-Atlantic these cultivars have performed the best in replicated trials by University researchers.

Greenix (NJ-1021) – *All male. Rust resistant and Fusarium tolerant.

Greenox (NJ-1122) – *All male. High yielding with excellent disease resistance, and good spear quality. Rust resistant and Fusarium tolerant.

Jersey Giant – *All male. Vigorous with high yields and excellent disease tolerance. Performs well in cooler climates. Purple bract color on green spears. Rust resistant and Fusarium tolerant.

Jersey Knight – *All male. Vigorous with high yields and high disease tolerance. Performs well in warmer climates. Spears are green with purple bracts. Most experts believe that it has the best spear quality of the NJ asparagus selections. Rust resistant and Fusarium tolerant.w

Jersey Supreme – * All male. High producer with vibrant green stalks. Rust resistant and Fusarium tolerant.

Millenium – Canadian cultivar (predominantly male) tolerant of cold winters and hot summers. Plants are rust resistant and yields well in medium to heavy soils.

Purple Passion – Good purple color. Considered tender and sweet

Sequoia (NJ-1113) - *All male. Reportedly yield 30% more than Jersey Giant. Rust resistant.

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

Spartacus (NJ- 978) – *All male. Adapted to cold winters and warm summers. Purple tinged tips. Spears are thick and uniform.

Asparagus Culture

Asparagus prefer a deep, well-drained sandy loam soil but will tolerate heavier soils as well. Soil testing should be undertaken one year prior to planting so that the soil can be amended before planting. Perennial weeds can also be a problem in asparagus fields so perspective growers should consider using a non-selective systemic herbicide a year before planting to control any existing perennial weeds. Cover crops should be established about one year before planting asparagus to increase soil organic matter levels and to reduce weed pressure. Winter wheat or cereal rye can be planted in the fall before planting asparagus and can be plowed down in the spring in preparation of the asparagus planting.

Asparagus plants prefer a soil pH between 6.7 to 7.0 and will not grow well if the soil pH is below 6.0. Fusarium crown and root rot survives in the soil at low soil pH's. If the selected field has a history of Fusarium crown and root rot a grower may elect to raise the pH of the soil to 7.0 -7.5 to reduce the survivability of Fusarium in the soil.

Phosphorous and potassium are essential to the successful establishment and growth of asparagus. Growers should ensure that the soil has 250 pounds of available Phosphorous and 300 pounds of available Potassium per acre. Asparagus are light feeders and will require 70 pounds of nitrogen per acre prior to planting.

Asparagus can be established in the field using three methods (direct seeding, seedling transplants, crowns), but the primary method utilized by growers in the Mid-Atlantic is the planting of dormant 1-year old crowns. One-year-old crowns are more economical and higher yielding than more mature 2-3-year-old crowns. Asparagus crowns are typically spaced 12-18" apart in the rows and the rows are spaced 5-6' apart to accommodate equipment and to prevent excessive shading by the asparagus plant canopies. Asparagus rows should have a north-south orientation to afford better drying and improved air circulation.

Asparagus crowns should be planted when the soil temperatures are at least 500F. Planting asparagus crowns in cool, wet soils can lead to infection from Fusarium crown root. Asparagus crowns should be sorted and graded prior to planting. Crowns of equal size should be grouped and planted in the same row. If undersized crowns are planted adjacent to larger crowns they will be shaded by the ferns from the larger plants and will perform poorly.

Asparagus crowns should be planted in a furrow that is created using a lister plow. Furrows for the planting of asparagus crowns should be 6" deep on sandy soils and 4-5" in heavy, deep soils. Phosphorous is critical to the long-term establishment and profitability of asparagus. Apply 100 pounds of 0-46-0 per acre at the bottom of the furrow prior to planting the asparagus crowns to ensure Phosphorous availability. The crowns should be placed (upright for faster emergence) in the furrow directly on top of the fertilizer.

Asparagus crowns should be covered with a few inches of soil after planting and the furrows should be filled in gradually until the furrow has been filled in completely (ground level). Under good growing conditions new asparagus spears will emerge through the soil in 1-2 weeks after planting.

Asparagus cannot be harvested the year of crown planting in order to facilitate the development of a good root system. As a rule, growers can harvest asparagus for 2-4 weeks the year after crown planting and 4-6 weeks the second year after crown planting. In subsequent years (7-20) growers should be able to harvest asparagus for 6-8 weeks. A better indicator of when to end harvesting asparagus is when ¼ to ¾ of the emerged spears possess a spear diameter of 3/8 inch.

Asparagus should be harvested in the morning when the spears are cooler and turgid. Only harvest spears when the heads are tight (prior to them "ferning out"). Under cooler temperatures asparagus may only need to be harvested 2-3 times a week. If the weather is warm a grower may need to harvest twice-a-day (morning and evening).

Asparagus spears can be cut or snapped when harvesting to produce a marketable spear ranging from 7-9". Asparagus that is snapped does not have a white fibrous butt end and has less trim when compared to asparagus that is harvested via cutting.

Post-harvest Handling of Asparagus

Post-harvest handling and grading of asparagus is critical to preserving its value in the marketplace. Harvested asparagus quality drops dramatically when the air temperatures surrounding it are above 400 F. Asparagus spears should be protected from the sun (after harvest) and should be immersed in ice cold water (360 F) or hydrocooled for 10 minutes. Coolant water used in immersion tanks or hydrocoolers should be chlorinated at a level of 125 ppm to protect the asparagus spears from both fungal and bacterial decay organisms. Longer term storage of asparagus can be achieved by storing the asparagus spears upright in a cooler where the air temperature is maintained at 32-340 F with a relative humidity of 95%. Storage temperatures below 340F for 10 or more days can result in chilling injury on the asparagus spears rendering it unmarketable. Asparagus spears held at room temperature become tough and lose sugar content which impacts consumer satisfaction.

Asparagus are usually displayed at the retail level in one-pound bunches in refrigerated display racks with their butt ends standing in ice water or in shallow trays to maintain turgidity in the spears. Asparagus spears should be 7-9" in length, no less than ½" thick at the base, free of injury and damage, and relatively straight in appearance when sold to consumers.

White Asparagus Production

White asparagus is a specialty produce item in the U.S. market that can command a price that is 2-3 times that of the fresh market price of green asparagus. White asparagus is essentially green asparagus that has been produced/harvested in the absence of sunlight. Specialized hoop structures with opaque row covers and/or mounds of soil are placed over the rows of asparagus prior to spear emergence. When the spears emerge from the soil under these opaque row covers or mounds of soil the asparagus lacking chlorophyll (due to the absence of light) and will appear white. The use of mounds of soil over the asparagus rows is very labor intensive and will require that the excess soil be removed at the conclusion of the harvest season. The use of opaque row cover over hoops is labor intensive, but their erection prior to harvest and removal after the harvest season is less intensive than the mounding technique. Small growers looking to increase the value of their asparagus for restaurant and/or specialty markets should consider this production technique.

Reverse Asparagus Production

Asparagus production is considered a spring or early summer crop, but entrepreneurs are utilizing innovative techniques to produce fresh cut asparagus outside of its normal harvest period. Entrepreneurs wishing to produce a late summer to fall crop of fresh asparagus allow the asparagus plants to go straight to fern when they emerge in the spring. These growers allow the asparagus to grow naturally until a predetermined point in the summer (grower decided) when they mow off the tops and begin to harvest for approximately 4 to 8 weeks. By electing which sections to mow off at a time the grower can push their harvest into fall if unprotected or into late fall with a movable high tunnel.

Literature Cited

1. Cantaluppi, C.J., and R. J. Precheur. 1997. Asparagus Production, Management, and Marketing, Bulletin 826, The Ohio State University
2. "Snapshot of Global Asparagus Cultivation." www.eurofresh-Distribution.com/News/Snapshot-Global-Asparagus-Cultivation, 15 Apr. 2016, www.eurofresh-distribution.com/news/snapshot-global-asparagus-cultivation.
3. "UK Asparagus Grower Extends His Season." Vegetable Growers News, 14 Nov. 2008, www.vegetablegrowersnews.com/article/uk-asparagus-grower-extends-his-season/.
4. Weston, R. 2014. White Asparagus Production for the Gourmet Market, Nuffield Australia Farming Scholars

BIOLOGICAL/BIOSTIMULANTS IN CROP PRODUCTION

M. D. Orzolek
Prof Emeritus Vegetable Crops
Plant Science Department
The Pennsylvania State University, University Park, PA
mdo1@psu.edu

So everybody is on the same page, I will define biologicals and biostimulants that are currently being used in industry.

BIOLOGICALS

Biologicals are defined by several large agricultural companies as an umbrella term for microbial, plant extracts and other materials that are used by farmers to increase plant health and productivity. Specifically, microbials are bacteria,fungi, nematodes, protozoa and viruses - all living organisms - used in the formulation of microbial products. There are many spore forming and non-spore forming bacteria that are known to be effective against a wide spectrum of insects and diseases as well as physiological processes in plants during growth and development. Bacillus thuringiensis is an example of a beneficial bacteria that controls several insects when applied to plants.

Fungi have complex lifecycles and some are parasitic to various plants and insects. Fungi require specific environmental conditions to proliferate and their means of affecting target plants and pests are very diverse. All these microbes are present in the soil in a population of millions in a gram of dry soil. Algae is generally found in the upper inch of arable soils. There are three general groups: blue-green, green and diatoms. All of the ordinary types of algae are stimulated by the application of farm manure.

A small family farm (Dean Glenney) in southwest Ontario may hold the most striking example in Canada of what happens when cultivated land is allowed to return to its "natural biological" condition. Soil tests were taken 60 days into the 2012 season by the A & L research director that demonstrated the values of microbes in the soil. The corn in Dean Glenney's high-yield soil displayed s very different spectrum of microbial activity from corn planted in a nearby, low-yielding field. Glenney's corn field had only seven bacterial families. The nearby low-yielding field had 26 bacteriaal families. However, the total bacterial population was 100 times larger in the Glenney high-yielding soils. It was also noted that in the Glenney corn field, the corn roots had taken up 95 percent of the available nutrients in the soil while in the nearby low-yielding field, only 60 percent of the available nutrients in the soil had been taken up by the corn roots.

Field trials conducted at the Horticulture Research Farm at RockSprings, PA with a microbial formulation on soil has increased soil tilth compared to untreated soil and has also increased the water holding capacity of the treated soil. Applications of the microbial product over several years is more effective compared to only a single application to soil over time.

BIOSTIMULANTS

Biostimulants are defined by Russo and Berly (1990) as products that, when applied to plants, reduce the need for fertilizers and increase their productivity and resistance to water and climatic stress. The use of organic biostimulants are used to help low input sustainable agriculture.

The major plant biostimulants are humic and fulvic acids, protein hydrolysates, seaweed extracts, silicon, chitosan, inorganic compounds, beneficial fungi

(i.e., arbuscularmycorrhizal fungi; AMF and Trichoderma spp.) and plant growth-promoting bacteria. Biostimulants may be of natural or synthetic origin and contain both organic and inorganic compounds. Natural biostimulants are based on free amino acids, humic compounds, fruit or seaweed extracts, chitin and its derivative-chitosan, or effective microorganisms

Michael D. Orzolek is Professor Emeritus of Vegetable Crops, Department of Plant Science, The Pennsylvania State University. He came to Penn State in 1981 with a three-way appointment – 60% Extension, 22% Research and 18% Teaching. Since his retirement in July, 2012, he has kept active conducting applied field research and moving his office to the Horticulture Research Farm, Rock Springs, PA. He has done extensive research on stand establishment, plastic mulches, high tunnels, weed management and tillage systems. Mike is still the current Director of the Penn State Center for Plasticulture and the CP High Tunnel Research and Education Facility at Rock Springs, PA.

On the other hand, synthetic bio-stimulants contain growth regulators, phenolic compounds, inorganic salts and beneficial nutrients such as Al, Co, Na, Se, Ti, Si. Bio-stimulants seem to be more effective with plants that are particularly sensitive to adverse climatic conditions and are economically important. In this regard, biostimulants seems to be effective in regulation/modification of physiological processes in plants to stimulate growth, to mitigate stress induced limitations, and to increase yield. Several factors can be attributed to the increase in plant nutrient uptake, such as an increase in soil enzymatic and microbial activities, modifications in root architecture as well as an enhancement in micronutrient mobility and solubility.

Humic substances are the most widely distributed organic carbon-containing materials on the earth's surface, occurring in soils, fresh waters and in the sea. They constitute between 78 to 80% of the organic matter in most inorganic soils and are formed from the chemical and biological degradation of plant and animal residues and from synthetic activities of microorganisms. The remaining 20 to 30% of the organic matter in soils consists mainly of protein-like materials, polysaccharides, alkanoic acids and alkanes.

Humic acids appear to have a greater effect on plant roots rather than the above ground parts of plants. Stems seem to be less affected than leaves. The intensity of the effect of humic acid on plants depends upon the plant species. According to their reaction towards humic acids, four distinctive groups of plants have been identified:

1 - carbohydrate-rich plants (potato, sugar beet, tomato and carrot) which react strongly and by which, under optimum conditions, a 50% higher yield could be expected.

2 - cereals such as barley, maize, oats, rice and wheat react well with humic acids.

3 - protein-rich plants (green beans, lentils and peas) react slightly with humic acids.

4 - oil-yielding plants (castor oil plant, cotton, linseed and sunflower) react very slightly to humic acid or evenly negatively affected.

Dr. R. O. Russo and Dr. G. P Berlyn. 1990. Th Use of Organic Biostimulants to Help Low Input Sustainable Agriculture. Journal of Sugriculture. Volume 2, pages 19 to 42.

DISEASE MANAGEMENT IN COLE CROPS: ALTERNARIA BLACK SPOT AND BLACK ROT

Francesca Rotondo and Sally A. Miller
Department of Plant Pathology, The Ohio State University
1680 Madison, Ave., Wooster, OH 44691
rotondo.11@osu.edu

Two of the most common and potentially damaging diseases of cole crops are black rot and Alternaria leaf spot. Both of these diseases can be found in most any cole crop – cabbage, cauliflower, broccoli, Brussels sprouts, collards, kale, etc. Black rot is caused by a seedborne bacterium, Xanthomonas campestris pv. campestris. Alternaria black spot is caused by two species of the fungus Alternaria – A. brassicae and A. brassicicola, which may also be seedborne. Other diseases of cole crops caused by bacteria are peppery spot and bacterial soft rot. Diseases caused by fungi/oomycetes include white mold, downy mildew and clubroot. Integrated management from seed to harvest is necessary to maintain crop health and reduce risk of economic loss. Although the various cole crops are very different products, they are generally susceptible to the same diseases and management practices are similar.

Black rot. Black rot is arguably the most important and damaging disease of cole crops. It is favored by warm, humid conditions and spreads readily from plant to plant through splashing rain. The bacterium enters plant tissue through wounds and natural openings. Typical symptoms are necrotic spots with chlorotic lesions and necrotic V-shaped lesions with chlorotic halos at the leaf margins (Fig. 1A). The bacteria move systemically, and infected plants become stunted and may die. In established infections, leaf veins turn black in color (Fig. 1B). The bacteria can survive on seed for several years and in soil associated with plant residue for a shorter time. It also survives in weeds in the Brassica family. Bacterial diseases are initially diagnosed by checking for the presence of bacteria streaming from lesions or blackened veins (Fig. 1C).

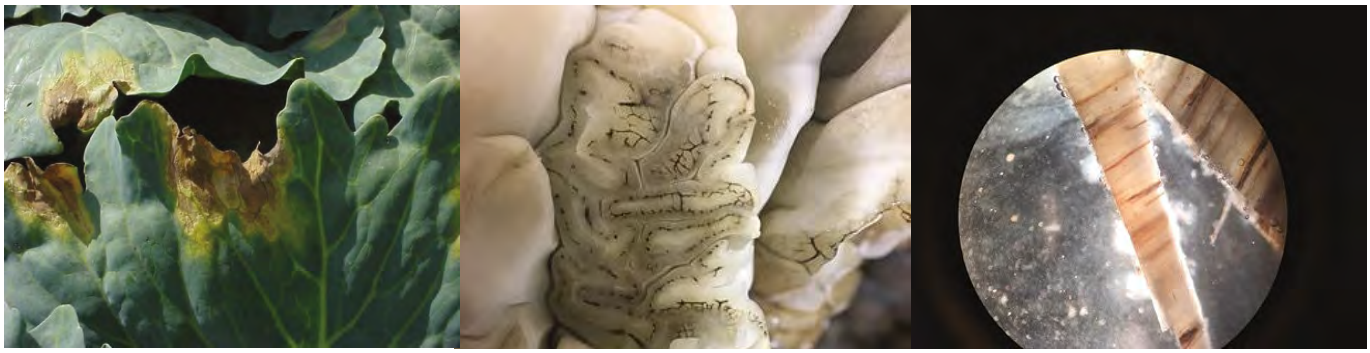


Figure 1. (A) Typical marginal V-shaped black rot lesions in cabbage; black veins in severely affected cabbage head leaves; (C) bacteria streaming from infected cabbage veins

Alternaria black spot. This disease affects all cole crops and can drastically reduce the quality of the produce. Leaf lesions are necrotic and zonate, usually with intense chlorotic halos (Fig. 2A, 2B). The pathogen is a common

Dr. Francesca Rotondo is a Research Associate in Dr. Sally A. Miller's research group in the Department of Plant Pathology at The Ohio State University, Wooster, OH. She received her degrees from the University of Bologna, Italy (B.Sc. in Biology, M.S. in Environmental Ecology, and Ph.D. in Plant Pathology). Both her Ph.D research, at the University of Bologna, and her postdoctoral research, at the University of Arizona, focused on Alternaria systematics. Her research in Dr. Miller's lab focuses mainly on bacterial diseases of tomato and their management, specifically bacterial leaf spot caused by Xanthomonas spp. Under the leadership of Dr. Miller, Dr. Rotondo coordinates the OSU Vegetable Pathology Lab's diagnostics services, being actively involved in the diagnostic process and interactions with growers and Extension educators.

A B C

Figure 3. Alternaria black spot of cabbage (A) and collards (B). Note brown zonate lesions with yellow haloes. Alternaria black spot of cauliflower (C).

inhabitant of soil, associated with plant residue. Spores are produced in large numbers on decaying plant material and are spread by air currents and splashing rain. Older leaves are more susceptible to the disease than younger leaves, so the lower leaves are usually infected first (Fig. 2A, 2B). Heads of cauliflower and broccoli may be made unsaleable due to the presence of black, sporulating lesions (Fig. 2C).

6-Step Integrated Disease Management Program

1. Use Clean Seed

The first step in prevention of diseases is to exclude pathogens from the crop. Obtaining clean seeds should be a first priority. While sanitizing seed treatment is mainly suggested to remove pathogenic bacteria, these treatments may also be helpful in destroying certain seedborne fungi and viruses. If seeds are purchased, they should be obtained from a reputable producer with a good track record for selling high quality seed. Ideally, the producer will have tested a sample of the seeds for the presence or absence of target pathogens. If they have been tested and the results are negative, there is a relatively low risk that the pathogen may be present. If they have not been tested, seeds should be treated to kill pathogens on the surface. If seeds are saved by the farmer from the previous year's crop or obtained from a source with an unknown track record, they should always be treated. Clorox and hot water seed sanitizing protocols can be downloaded from: https://u.osu.edu/vegetablediseasefacts/management/chlorine-seed-treatment/. Some seed companies routinely treat seeds of cole crops to eliminate the black rot pathogen.

2. Choose a Resistant Variety

It is unlikely that a variety can be identified that has resistance to all problematic diseases that can be encountered during a growing season. However, some varieties have resistance to one or more important pathogens. Cabbage varieties with resistance to black rot are available. Resistance to Alternaria black spot is not common in cole crops.

3. Use Pathogen-Free Transplants

The greenhouse environment in which seedlings are produced, if not managed properly, is highly conducive to diseases, particularly black rot and black spot. Bacteria present on only a very small number of seeds (e.g. 1 in 10,000) can become a significant threat in some greenhouses. The following practices will reduce the threat of diseases: 1) use of new or sanitized plug trays or flats and pathogen-free mixes, 2) sanitizing equipment, installing solid flooring and raising trays from the floor, 3) limiting movement of personnel and equipment between greenhouses, and 4) cleaning benches and greenhouse structures thoroughly after the crop. Since disease development and spread is promoted by wet conditions, relative humidity should be low, air circulation should be high and plants should be watered only enough to ensure growth and minimize the risk of drought stress. Surface water (from ponds, lakes, rivers, etc.) or re-circulated water should never be used to irrigate seedlings unless it has been treated (e.g. ozone, chlorine) and is tested regularly to assure that pathogens are killed. Farmers who purchase transplants from others should ask about their management practices, and visit them during transplant production.

4. Choose the Best Site and Rotate

Crop rotation is an important strategy that not only reduces disease problems but also affects weed, insect and nutrient management. Crop rotation should be done between crop families; cole crops and other Brassica crops are in the same group and should never be grown after each other in a rotation. The minimum time away from cole crops and other Brassica crops should be 3 yrs to suppress development of black rot, Alternaria black spot and other diseases. Site factors that minimize opportunities for disease development include good drainage and good aeration.

5. Use Appropriate Cultural Practices

There are a number of cultural practices that can help to improve overall plant health and also reduce disease development. Our research has shown that increasing the organic matter content of soil not only improves crop growth and yield, but may also reduce some diseases. Organic amendments such as high-quality compost and manures should be considered if available within a practical distance from the farm. Organic amendments are best applied in the fall or early spring to allow leaching of excess salts and destruction of pathogens. Care should be taken with any fertilizer program to avoid excessive nitrogen, which can increase plant susceptibility to soft rot and other diseases. Irrigation should be carefully controlled to minimize the time that plants are wet. Acidic soils should be limed to achieve a neutral pH if clubroot is a problem. Weed control in and near fields is also necessary to limit opportunities for pathogen populations to increase on susceptible weed hosts.

6. Use Crop Protectants as Needed

Applications of copper-based fungicides/bactericides are not effective against bacterial soft rot, but may reduce spread of black rot or peppery spot under low disease pressure. In our 2019 trials, and under low-moderate disease pressure, the biocontrol product Stargus alone or in combination with Regalia or Badge X2 (copper hydroxide + copper oxychloride) significantly reduced black rot in cabbage compared to the non-treated control. The fungicides Fontelis, Quadris Top, Inspire Super and Endura controlled low-moderate levels of Alternaria black spot in cauliflower and cabbage in our trials. To avoid development of fungicide resistance in the pathogen populations, each of these fungicides should be tank mixed with another effective fungicide with a different mode of action.

OPTIMIZING COLE CROP FERTILITY

Steve Reiners
Horticulture/School of Integrative Plant Science, Cornell University
Cornell AgriTech, 635 West North St., Geneva, NY
sr43@cornell.edu

When it comes to a soil fertility plan for cole crops, there are a few complicating factors. First, cole crops include obvious commodities like cabbage, broccoli and kale but also radishes and turnips. They range from long season, heavy feeders to short season, light feeders. They respond to micronutrients like boron and molybdenum and are affected by drought induced deficiencies of calcium. They are also a group of crops in which soil pH can have an impact on diseases like Clubroot. As with any vegetable crop, let's start with the optimum pH.

Like most vegetables, all the cole crops do best with a pH around 6.5, just slightly acid. There's nothing magical about that pH, but it is the level where all the nutrients plants need have their maximum availability. In addition, microbes that feed on organic matter and make nitrogen available are happiest at that pH. Get the pH too low, close to 5.5, and calcium, magnesium, and molybdenum are less available. But some nutrients like manganese, iron and aluminum become to accessible and may become toxic. Get the pH above 7, and phosphorus, boron, zinc and manganese aren't available.

Of course, a good soil fertility program starts with a soil test and you should try to test your soils at least every three years. And because of the reasons I mention above, the pH may be the single most important thing to know about your soil. Generally, in the northeast, our soils get a bit more acidic over time and limestone is needed. The amount is dependent on your soil type and starting pH with greater amounts needed on heavier soils. If limestone is needed, check your soil test for the calcium and magnesium levels. If magnesium is needed, use a dolomitic lime. If magnesium levels are fine, use a calcitic one. Since lime reacts very slowly with soil, the ideal time to apply is in the fall. But if spring applied, try to spread prior to working the soil. This will ensure that spring plowing/disking mixes the lime into the soil and changes the pH throughout the acre furrow slice.

Most conventional growers will use chemicals to manage Clubroot, a soilborne disease that can leave roots with large galls that eventually wilts and kills the plants. Organic growers can adjust the pH to 7 to 7.2 which will inhibit the disease. But if you do that, additional phosphorus, boron, zinc and manganese may be needed.

Cole crops need higher amounts of boron than many other vegetables, usually benefitting from an additional 1 to 2 pounds of actual boron on heavier soils and 2 to 3 pounds on lighter, sandy soils. Boron deficiency symptoms include brown, hollow stems in broccoli and cauliflower along with callused stems. Boron can be applied as a broadcast application with other fertilizers in the spring or as a foliar application later in the spring. If using foliar applications, rates should be reduced significantly to reduce toxicities, with rates of only 0.1 to 0.3 pounds per acre of actual boron applied.

> Fertilizer dealers and soil test labs often talk about the "actual pounds of an element per acre". That allows growers to adjust rates based on the fertilizer being used. If you want to add "1 pound of actual boron per acre" and you are using Borax that contains 11% B, you would need about 9 pounds of Borax (1 ÷ 0.11 = 9.09). If using Solubor at 20% B, you would need only 5 pounds of Solubor (1 ÷ 0.2 = 5).

Droughty conditions may induce boron deficiencies but are more likely to induce calcium deficiencies, as indicated by tipburn - dried, brown, papery looking areas on leaf edges. Most of our soils in the northeast have lots of calcium so the problem comes about when water uptake is limited as calcium moves with the water in plants. Maintaining

Steve Reiners is Professor and Chair of the Horticulture Section at Cornell's School of Integrative Plant Science. He has been at Cornell since 1994 and serves as the statewide vegetable specialist. His research and extension program focuses on soil fertility, variety evaluations, stand establishment and plasticulture. He is originally from New Jersey and received his BS and MS from Rutgers University and his PhD from Ohio State.

uniform soil moisture will be much more effective than adding additional calcium with foliar sprays.

Molybdenum deficiency may be seen on cole crops on light soils where pH is low (perhaps in rotation with potatoes), resulting in a problem called "whiptail". The leaves are thin and strap like and yields are significantly reduced. Maintaining the proper pH is the best way to minimize the problem but if that can't be done, a foliar application of only 2 to 3 ounces of sodium molybdate per acre is enough for most crops.

Research is being conducted at Cornell on whether sulfur needs to be part of a fertility program in vegetable crops. For more than a century, high sulfur fuels were used in power plants in the midwest, resulting in sulfur raining out of the sky in the northeast. The Clean Air Act has resulted in less sulfur deposition and we have seen some crops like alfalfa respond to additions of 30 to 40 pounds of sulfur per acre (often in the form of gypsum). Deficiencies would first be seen on lighter textured soils and fields with no manure history. If sidedressing nitrogen, use ammonium sulfate to provide both N and sulfur.

Recommendations for nitrogen, phosphorus and potassium are included below. Low soil potassium with high soil phosphorus may result in black petiole on cabbage, especially storage cabbage

Table 1. Recommended nutrients based on soils tests – direct seeding

Recommended (lb. N/acre)	Recommendation (lb. P_2O_5/acre)			Recommendation (lb. K_2O/acre)		
	Low	Medium	High	Low	Medium	High
Broadcast and disk-in						
40	80	40	0	120	80	20
Band place with planter if seeding; if transplanting broadcast immediately before planting						
40	40	40	40*	40	40	40
Sidedress 4 weeks after seeding or 2-3 weeks after transplanting						
20-40	0	0	0	0	0	0

*if phosphorus levels are high, high P starter solution may provide adequate P nutrition

LEPIDOPTERA MANAGEMENT 101

David Owens
Delaware Cooperative Extension Specialist, Entomology
Carvel Research and Education Center
16483 County Seat Highway, Georgetown, DE 19947
owensd@udel.edu

Brassica crops are attacked by as diverse a group of insects as there are different types of brassicas. Each pest presents its own management challenges. Aphids, flea beetles, root maggots, stink bugs, leafminers, and a diverse group of caterpillar species can cause damage to the crop. Of the Lepidoptera, the most commonly encountered pests, and those which drive many insecticide management programs, are imported cabbageworm, cabbage looper, and diamondback moth. Basic identification, life histories, and biological control agents will be discussed, with emphasis on how management is impacted.

Lep thresholds for heading brassicas are 20% infested plants early, but thresholds decrease to 5% infested plants during early head formation. Thresholds for leafy brassicas are 10% infested plants, but this may be lower for processing vegetables. Five management tactcs to prevent insect damage will be discussed: crop destruction, variety selection, trap cropping, chemical management, and row covers.

Brassica varieties may exhibit different susceptibility to pest attack, especially when grown next to each other. In many cases, a variety may be less favored by one pest in the complex, but be as attractive to the rest of the complex. For example, in Hawaii, 'Scorpio' cabbage was much less susceptible to DBM than the then industry standard 'Tastie' cabbage. Older literature from NC lists a couple of cabbage varieties that are less susceptible to cabbage looper and diamondback moth. At the Carvel REC, harlequin bug numbers infesting a Brussels sprouts variety trials appeared to differ depending on variety, and a planting of 'Savoy Ace' cabbage sustained less worm injury than 'Early Round Dutch,' but it is unclear how insects would respond in large, single-variety fields.

Trap cropping is an extension of brassica variety preference for management. Various scientists have at one time or another used collards as a trap crop to protect cabbage from DBM and harlequin bug. Chinese mustard can be used for flea beetle control. Glossy-leaved 'Yellow rocket' can be planted around cabbage to protect from DBM and flea beetle. Recent Virginia Tech research (Anna Wallingford now at NH and Tom Kuhar) demonstrated that mustard can be used to protect collards from harlequin bug damage. Trap cropping is more effective when treated with insecticides. Trap cropping arrangement will be briefly discussed.

There is a wealth of insecticide mode of actions available for Lepidoptera management. They should be incorporated into a spray program in a way to preserve beneficials and delay risk of resistance. Broad spectrum insecticides such as the pyrethroids should be preserved for late in the season to limit impact to beneficial insects. Modes of action should be rotated between sprays and between 30-day windows, which is the approximate time for a generation of diamondback moth. Methods to improve chemical management include the use of spread/stickers and modifying booms to achieve good coverage. Spray trial data will also be discussed.

David Owens is the University of Delaware's Agricultural Entomology Extension Specialist and is located at the University of Delaware's Carvel Research and Education Center in Georgetown. Starting in 2017, he has been providing extension education and support for Delaware field and vegetable crops. He conducts pest surveys of sweet corn, watermelon, small grain, soybean, and sorghum and conducts IPM and efficacy trials in cole crops, sweet corn, watermelon, and legumes. He contributes regularly to the UD Weekly Crop Update. He received his bachelor's and master's degree from Virginia Tech and his doctorate from University of Florida and worked as a postdoc with USDA-ARS in Florida working with avocado pests and at NC State working with tomato pest management. He and his wife, Beth, have two children, Hazel (3) and Jack (1).

Table 1. Collards data from Tom Kuhar (VT). Collards planted on 19 May 2016, treated on 1 June and 10 June. All treatments included Scanner spreader sticker 0.25%.

		Mean no. total lepidopteran larvae* / 5 plants				% unmarketable leaves
Treatment	Rate / acre	9-Jun	15-Jun	22-Jun	29-Jun	
Untreated check		9.3 a	8.8 a	1.8 a	9.8 a	67.5 a
Endigo ZC	4.0 fl. oz	0.0 b	0.0 b	0.3 b	2.5 b	25.0 abc
Intrepid Edge	8.0 fl. oz	0.0 b	0.0 b	0.3 b	2.5 b	17.5 abc
Radiant	5.8 fl. oz	0.0 b	0.5 b	0.0 b	1.8 b	7.5 c
Coragen	4.8 fl. oz	0.3 b	0.3 b	0.0 b	0.3 b	12.5 bc
Avaunt	7.0 oz	0.3 b	0.8 b	0.0 b	3.3 ab	50.0 ab

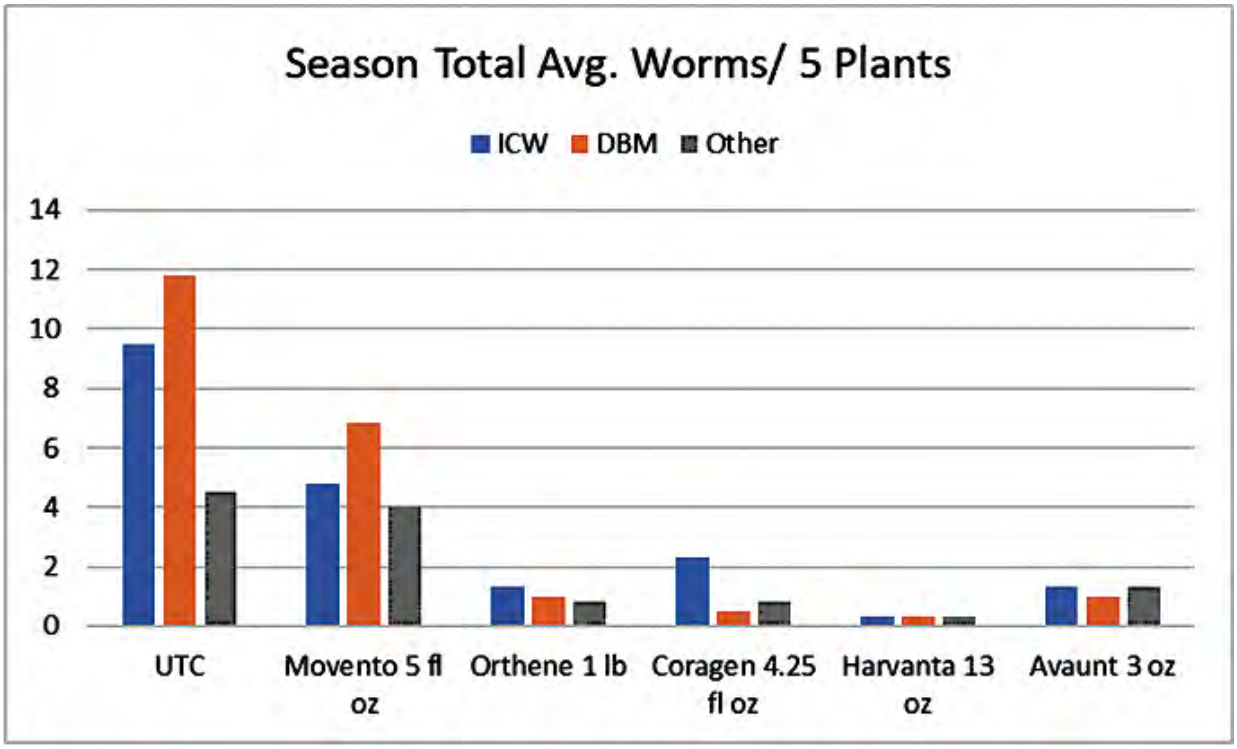


Figure 1. Average season total number of worms from 5 'Early Round Dutch' cabbage plants in the UD cabbage trial, 2019. Treatments were applied on 17 Sept, 25 Sept, and 11 Oct. Plots harvested on 23 Oct and included Induce.

SOIL HEALTH BENCHMARK STUDY

Franklin Egan
PA Association for Sustainable Ag (PASA)

Soil health is the foundation of sustainability on any farm, and farmers need a clear understanding of the status of their soil resources to manage for the future. Since 2016, PASA has been working through our Soil Health Benchmark Study to document and improve soil health outcomes through farmer-generated data. In 2018, we worked with 34 diversified vegetable farmers, 15 row crop farms, and 8 grazing dairies to quantify soil health using field samples and farm records for practices including cover cropping, soil disturbance, and soil amendments.

Based on the Cornell Comprehensive Assessment of Soil Health, we found that despite a range of cropping systems, farm scales, and management techniques, most of our farms showed excellent to optimal organic matter ratings (medians of 95, 96, and 100 on Cornell's 100-point scale for vegetable, row crop, and grazing farms, respectively). Vegetable and row crop farms tended to have low soil protein (medians of 52 and 49, respectively) and microbial respiration (median of 45 and 59, respectively) ratings and poor aggregate stability ratings (median of 27 and 36, respectively). Grazing farms tended to have opting ratings (scores of 80 and higher) for all of the 12 soil health indicators in Cornell's "standard package," demonstrating the power of perennial systems. Surprisingly, we found that on vegetable and row crop farms, intensive tillage was often compatible with high organic matter ratings (sometimes even without inputs of compost, manure or other off-farm organic matter sources), although aggregate stability ratings were typically lower on farms with intensive tillage.

These data suggest that different farming systems can successful apply different techniques and strategies to grow soil health. We also bring our farmer collaborators together for field days and workshops that use these data to guide discussions and collaboratively generate new ideas for improving soil health. In 2019, we grew our project to 100 participating farms, and we are currently analyzing soil test and management record data.

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

PUMPKIN GAMES: WORTHWHILE FUN WITH WORTHLESS PUMPKINS

Jeffrey Stoltzfus
Penn State Extension
Rhonda Stoltzfus
Glen Run Valley View

It was early November, 20 years ago and we were in charge of finding an interesting way to entertain middle school kids from our church. Our pumpkin stand was still full of, now worthless, pumpkins. Rhonda had the bright idea of "let's make up some pumpkin games" We will do it in the meadow and the cows can clean up the mess. The part about no mess to clean up appealed to me and so our annual pumpkin festival was born.

It grew quickly to involve the entire church. Then we invited friends and neighbors and they invited friends and neighbors. After 10 years we were hosting 200 people at our farm to play with pumpkins. Up to this point it was just a fun afternoon party. But as it grew it became a lot of work as each year was full of new ideas. We eventually came to the point, where we decided we needed to quit or get bigger. When we decided to get bigger, we decided to do it as a fund-raiser for local non-profits. The groups we help to fund provide volunteers for set-up, to operate the event and to help cleanup(although the angus beef cows still do most of that).

We have 2-3 local pumpkin chucking machines on hand demonstrating their machines. These are machines that have attended the National Pumpkin chucking competitions. It provides an opportunity for local folks to see the machines in action. Although not the riskiest event we do, it is what concerns the insurance folks the most.

The event runs from 11:00 AM-4:00 PM on the second Saturday in November. The event now features 20 different games which families can stroll through and play, all of which include pumpkins or gourds. Our special events area features pie eating contests and the finals of some of the races and throwing contests. We also do a cow patty bingo contest.

Our grand finale includes dropping a 800 pound pumpkin on a car followed by our Pumpkin Avalanche(as seen as YouTube). It involves rolling approximately 1,500 pumpkins down a steep 100 yard hill and watching them fly to pieces as they pick up speed. Folks seem to enjoy smashing the surviving pumpkins. Once the crowd clears our herd of 20 anxious cattle move in to begin their weeklong pumpkin binge.

Jeffrey Stoltzfus has been working as the Farm Food Safety educator for Penn State Extension in Lancaster County the past few years. Prior to that he spent 23 years as a farmer educator working for the Eastern Lancaster County School District working primarily with vegetable farmers in Eastern Lancaster County. He has assisted farmers in starting an onion growing cooperative and worked with them in areas of production and food safety.
Jeff and his wife Rhonda live on a small farm where they grow strawberries and pumpkins which they retail. They also raise beef cattle.

MANAGING FUNGICIDE RESISTANCE IN VINE CROP DISEASES

Margaret Tuttle McGrath
Plant Pathology and Plant-Microbe Biology Section, SIPS, Cornell University
Long Island Horticultural Research and Extension Center (LIHREC),
3059 Sound Avenue, Riverhead, NY 11901.
mtm3@cornell.edu

Best management program for several important diseases of vine crops is based on knowledge of occurrence of resistance in the pathogen, knowledge of resistance management strategies, and knowledge of new fungicides. Fungicides are the main tool for managing diseases due to their efficacy and the importance of managing diseases of foliage as well as fruit to obtain high yield of good quality fruit. Modern fungicides that are the foundation of conventional fungicide programs due to their inherent activity, have risk of pathogens developing resistance to them due to their single site mode of action. Some targeted fungicides have narrow activity necessitating applying multiple products when more than one disease is occurring. This is especially true with the most common diseases, powdery mildew (caused by a fungus) and downy mildew and Phytophthora blight (caused by oomycetes). Fungicides recommended routinely change as new products are registered and pathogens develop resistance to fungicides that have been in use for several years. Resistance to fungicides has been documented in pathogens causing powdery mildew, downy mildew, gummy stem blight/black rot, and Phytophthora blight affecting vine crops. Resistance is a concern with other pathogens being managed with fungicides that are considered to be at risk for resistance development.

Fungicide resistance management. The basic strategy to manage resistance is minimizing use of each fungicide chemistry in the management program that has resistance risk while striving for good control. This is achieved by using resistant varieties and other cultural management practices to reduce the need for fungicides and alternating among fungicides in different chemical groups based on FRAC code. Incorporate new, effective fungicides into the program. Rarely new fungicides are not as effective as older ones. Look for recommendations and information about efficacy from applied pathologists doing fungicide evaluations. Starting applications promptly at appearance of first symptoms or before disease onset (especially important with Phytophthora blight) and maintaining good control are important for managing resistance to keep the pathogen population small so there are fewer individuals being subjected to selection for resistance. Use high rate with fungicides labeled over a rate range. This is recommended to avoid selecting for isolates with intermediate resistance (able to tolerate low dose) when the type of resistance is quantitative as with FRAC code 3 (DMI) fungicides, but typically the type of resistance (quantitative versus qualitative) is not known until resistance develops. Strict alternation of fungicides with different FRAC codes often is recommended; this is based on the assumption that if a resistant isolate is selected by applying the first fungicide, the next fungicide applied will control it. Another idea for managing resistance is to apply each chemistry consecutively before alternating (block alternation); rationale is the dose of this chemistry will remain high on plant tissue for a longer period of time and there will be only once after the second application that the dose decreases to a level that could allow selection of any isolates with intermediate resistance. Many fungicides can be applied consecutively; twice is typically the label limit. Label use restrictions pertaining to alternations are to compel resistance management. Another common recommendation for managing resistance is tank mixing fungicides at risk for resistance with contact, protectant fungicides that have low inherent risk for resistance development (e.g. chlorothalonil and mancozeb). Whether it is better to apply the most effective fungicide in an alternation program primarily early or late in disease development is an important question. Better control of cucumber downy mildew was achieved when the most effective fungicide was applied later when disease pressure was increasing rather than in an early application soon after disease onset. Testing strategies to manage resistance is difficult, and it cannot be done until the pathogen has already developed resistance.

Powdery mildew is the most common disease of cucurbit crops because the pathogen produces an abundance of spores widely dispersed by wind and the pathogen doesn't require leaf wetness or high humidity to infect as others do. Only cultural

Meg McGrath is an Associate Professor with a research/extension appointment in Cornell University's Plant Pathology and Plant-Microbe Biology Section in the School of Integrative Plant Science. She is stationed at the Long Island Horticultural Research and Extension Center where she has been working since 1988 on optimizing management of diseases affecting vegetable crops. Research is being conducted within organic as well as conventional production systems. She has degrees from Pennsylvania State University (Ph.D.), University of Vermont (M.S.), and Carleton College (B.A.). Meg grew up in CT.

management practice is resistant varieties, which are available in most crop groups. Resistance in cucumber is standard in modern varieties and is so strong it is easy to forget this cucurbit type is susceptible until an Heirloom type is grown. Resistance in other cucurbits is not adequate used alone (without fungicides) to prevent impact of powdery mildew on yield. An integrated program with both resistant varieties and fungicides is recommended to maximize likelihood of effective control and to manage resistance as well as reduce selection pressure for isolates able to overcome resistant varieties.

Resistance has developed in this pathogen to six fungicide chemical groups: FRAC Code 1 (MBC fungicides; Topsin M), Code 11 (QoI fungicides; Quadris, Cabrio and Flint), Code U6 (Torino), Code 13 (Quintec), and to some fungicides in Code 3 (DMIs) and Code 7 (SDHIs). Fungicide resistance and efficacy have been studied at LIHREC for 30 years. This work documented control failure due to resistance to these chemistries by testing pathogen isolates from field plots where the fungicide was ineffective. Pathogen isolates collected every year from commercial and research fields are tested. Seedling bioassays are conducted in field plantings to assess resistance in pathogen populations. Recent results revealed that resistance in the pathogen to Code 1 and 11 fungicides and to the Code 7 fungicide boscalid (Endura, Pristine) have continued to be very common, therefore these continue to not be recommended for managing powdery mildew. Resistance to Code U6 and 13 has been found more commonly toward the end of the growing season. Fungicides in these groups are no longer recommended; growers with product left over could consider using at the start of powdery mildew development when resistant isolates have been less common. Testing isolates has revealed existence of isolates resistant to multiple fungicides in different chemical groups.

Recommended fungicide program to manage powdery mildew and fungicide resistance is to alternate among targeted, mobile fungicides in the 4 chemical groups below, and apply these with protectant fungicide. There are several protectants for powdery mildew, including chlorothalonil, sulfur, botanical and mineral oils, copper, and several biopesticides. Sulfur is most effective, but can injure cantaloupe leaves. Begin very early in disease development (one older leaf out of 50 with symptoms). Expect symptoms after plants start to product fruit.

Vivando (FRAC Code 50) has continued to provide excellent control in fungicide evaluations. Activity is limited to powdery mildew. Do not mix with horticultural oils. It can be applied three times per year with no more than two consecutive applications. REI is 12 hr. PHI is 0 days. Prolivo is a new Code 50 fungicide; it was tested at LIHREC in 2016 and found not to be as effective as Quintec; Vivando was not included in that evaluation.

DMI fungicides (Code 3) include Proline, Procure, and Rhyme (these are considered most effective) plus Aprovia Top, Folicur, Inspire Super, Mettle, Rally, Tebuzol, and TopGuard (also has Code 11 ingredient). Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Efficacy has varied in fungicide evaluations. Procure applied at its highest label rate provides a higher dose of active ingredient than the other Code 3 fungicides. Five applications can be made at this rate. REI is 12 hr for these fungicides. PHI is 0 - 7 days. Powdery mildew is the only labeled cucurbit disease for some of these; see last section for additional labeled diseases.

Gatten is in a new fungicide group (Code U13). Activity is limited to powdery mildew. It was not as effective as Vivando in a fungicide evaluation at LIHREC in 2018, but was as effective in a similar evaluation in 2019. Currently labeled for use on cantaloupe, cucumber, and squash. REI is 12 hr. PHI is 0 days.

Carboxamide fungicides (Code 7) include Luna fungicides (Luna Experience and Luna Sensation), Miravis Prime (also has Code 12 ingredient which targets other diseases), Fontelis, Endura, Pristine and Merivon. Powdery mildew pathogen strains resistant to boscalid, active ingredient in Endura and Pristine, have been detected since 2009 on Long Island and likely are the reason its efficacy has been poor in some fungicide evaluations. In laboratory assays boscalid-resistant strains exhibited sufficient cross resistance with Fontelis and Merivon that these are expected to be ineffective as well, but not with Luna fungicides. However, Luna Sensation failed in experiment at LIHREC in 2017. Luna Experience is the best choice. REI is 12 hr. PHI is 7. Maximum number of applications is 2-5, depending on rate used. Low rate is not recommended. Luna Experience also contains tebuconazole (Code 3), which needs to be considered when developing an alternation program. Luna Sensation is not recommended because it also contains trifloxystrobin (Code 11); resistance to this chemistry is very common. Limited use of Luna Experience is suggested.

Downy mildew is also primarily managed with fungicides due to lack of other management practices. Cucumbers with a new source of resistance are becoming available. Those that performed well in variety evaluations are DMR 401, NY264, Bristol and Citadel, which is a pickling type suitable for fresh market. Some suppression, albeit variable, can be obtained with varieties bred to be resistant to pathogen strains present before 2004. An important tool for determining when fungicide

application is warranted is the forecast web site for this disease at http://cdm.ipmpipe.org. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. Forecast system success depends on knowledge of where downy mildew is occurring; therefore, prompt reporting of outbreaks by growers to extension staff or the website is critical.

Resistance has been documented in the pathogen to fungicides in FRAC Codes 4 (e.g. Ridomil), 11 (Quadris), and 40 (Revus) and is suspected to have developed to other chemistry based on results from fungicide evaluations and fungicide sensitivity seedling bioassays conducted in several states recently. Poor to ineffective control has often been obtained with Forum (40) and Presidio (43), and less frequently with Previcur Flex (28) and Curzate or Tanos (both 27). Zampro (40+45) and Elumin (22) have sometimes exhibited poor control. Most effective fungicides are Orondis Ultra and Orondis Opti (49), Omega (29), Ranman (21), and Zing! (22). The pathogen is now known to exist as two host-specific clades and resistance / poor control has mostly been documented using isolates from cucumber and cucumber in fungicide evaluations and seedling bioassays. Cucumber is primarily infected by Clade A1 which also has been found on melons, except watermelon, which is infected by Clade A2 as are squashes and pumpkin. Fungicides ineffective on cucumber due to resistance may be effective on these other crops.

Phytophthora blight pathogen survives in soil with limited movement between farms, therefore fungicide use on a farm is a more important determinant of resistance occurrence on that farm than with the mildew pathogens. Resistance to FRAC Code 4 fungicides has been documented where they have been used repeatedly. Little additional research on resistance has been done with this pathogen. Resistance to Ranman and Presidio has been detected in the southeastern US. Other fungicides labeled and recommended for Phytophthora blight include Orondis Gold or Orondis Ultra (only one formulation can be used), Omega, Gavel, Zampro, and Tanos. Phosphorous acid fungicides (33) are recommended tank-mixed with these. There are many cultural practices for managing Phytophthora blight and thus resistance. Most focus on minimizing favorable conditions (saturated soil). More information about management and fungicides is at http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PhytoBlight_cucurbits-others.html.

Gummy stem blight / black rot pathogen has proven more adept at developing resistance than expected. Resistance has been documented to fungicides in FRAC Codes 1 (e.g. Topsin M) and 11 (Quadris), and to some fungicides in Code 7 (Endura, Pristine) and Code 3 (Tebuzol and others with tebuconazole). Fortunately, fungicides with new Code 7 chemistry (e.g. Aprovia and Miravis Prime) have been effective in fungicide evaluations where boscalid-resistant isolates are common. And Code 3 resistance so far has been found in only one of the three species of Stagonosporopsis causing this disease; however, with continued use of this chemistry over time resistance could become more common and also develop in the other species.

Two fungicide programs expected to provide good control are Inspire Super alternated with Miravis Prime and Switch alternated with Aprovia Top. Due to overlap in chemistry for some of these and need to alternate amongst chemistry (label use restrictions for resistance management), these are the best simple alternation options with these four. If GSB is occurring in a crop that commonly gets powdery mildew, then the first program is the best since Switch has no activity for powdery mildew. All can be applied at most two times sequentially before need to rotate. They can be applied four to five times, depending on product and rate, except Miravis Prime which can be applied only twice. Switch (FRAC code 9+12) is the only registered targeted fungicide with chemistry to which resistance has not been detected in the pathogen yet.

Sources of resistant pathogen isolates include on-farm selection from repeated use of a fungicide chemistry (the pathogen survives in soil) or selection on nearby farms (spores are dispersed short distances by wind and splashing water), seed contaminated with a resistant pathogen strain, and transplants infected when grown in a greenhouse where the pathogen is resistant. Crop rotation of at least two years is an important cultural practice to include in the management program for this disease and for fungicide resistance.

See http://vegetablemdonline.ppath.cornell.edu for more information about diseases of cucurbit crops and their management.

Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict due to label change or error. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

UPDATE ON INSECT PEST MANAGEMENT IN CUCURBIT CROPS

Thomas P. Kuhar
Professor – Dept. of Entomology, Virginia Tech
Blacksburg, VA 24061-0319
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 beetle**s (Acalymma vittatum and Diabrotica undecimpunctata howardi) are some of the earliest to attack most conspicuous pests. Adults (beetles) invade crops at all stages even at cotyledon, where large aggregations of beetles and their concomitant leaf feeding can kill seedling plants. Beetles also are the primary vector of the bacterial wilt pathogen, which can kill susceptible cucurbit varieties. Cucumber beetle adults and larvae (in the soil below mature fruit) may also feed on the rinds of fruit, causing direct damage to crops. Most conventional growers typically control cucumber beetles with neonicotinoids as either pretreatments on seeds such as such as Farmore F1400 (provides 3 weeks of protection) or drip chemigation of neonicotinoids, or spray foliar insecticides, usually pyrethroids (i.e., lambda-cyhalothrin, permethrin, bifenthrin, Baythroid XL, Mustang Max, Asana XL, etc.), which are quite efficacious and relatively cheap.

Cucurbit vine crops, especially pumpkins, squash, and zucchini, are also frequently attacked by s**quash bug** (Anasa tristis), which injures plants with its piercing-sucking mouthparts by feeding on the vascular tissues of cucurbit leaves and injecting a toxic saliva. Leaves with numerous squash bug nymphs on them often wilt and die under heavy feeding. This is known as Anasa wilt. Squash bugs usually invade crops later in their development after the neonicotinoid seed treatments have run out. Thus, their control often requires mid-season insecticide sprays after eggs have hatched and young nymphs are present. These insecticides typically include either pyrethroids or carbamates, which are also highly toxic to pollinators, and natural enemies that attack pest insects. Frequent applications of these types of insecticides will result in outbreaks of melon aphids, which produce copious amounts of honeydew resulting in sticky fruit or fruit with sooty mold growth on them. Thus, my lab is continuously investigating the most IPM-compatible and pollinator-compatible insecticide options for control. The results of a 2019 insecticide efficacy test conducted on squash in Virginia is presented below (Table 1). Results indicated that the more pollinator-friendly insecticide Sivanto provided some control of squash bugs, while Beleaf provided very little control of squash bugs particularly in comparison to the standard pyrethroid, bifenthrin. However, adding a 1/10th rate of bifenthrin to Beleaf provided effective control of squash bugs. Bifenthrin application will flare aphids, while Beleaf and Sivanto are excellent aphicides that will prevent aphid outbreaks.

Table 1. Summary of efficacy of insecticides for the control of squash bug on zucchini; Kentland Farm, Whitethorne, VA 2019. All insecticide treatments and the control included Dyneamic adjuvant at 0.5 % v:v.

		Squash bug nymphs per plant	
Trt (one spray on July 22)	**Rate/A**	**July 26 (4 DAT)**	**July 31 (9 DAT)**
Untreated Control	-	15.1 a	9.9
Beleaf 50SG (flonicamid)	2.8 oz	8.9 ab	7.0
Bifenthrin 2E (bifenthrin)	2.1 fl oz	0.0 c	0.3
Beleaf + Bifenthrin (1/10th rate)	2.8 oz + 0.21 fl oz	0.05 c	1.9
Sivanto Prime (flupyrifurone)	14 fl oz	4.4 bc	12.0
Sivanto HL	7 fl oz	4.9 bc	6.0
P-value		0.0072	NS

All data were analyzed using analysis of variance procedures. Means were separated using Tukey's HSD at the 0.05 level of significance. Means followed by the same letter within a column are not significantly different (P>0.05).

Tom Kuhar is a Professor and Vegetable IPM Specialist 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 insect pests of potato and vegetable crops. He has trained over 20 graduate students and has published over 120 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

Recently in Virginia, growers have faced issues with a much different pest, pickleworm (Diaphania nitidalis), which is a tropical moth pest of cucurbit crops including pumpkins, squash, and cucumbers. It is typically a pest in the southern U.S. and does not overwinter in the mid-Atlantic states, but occasionally it makes its way northward in late summer on wind and storm fronts. Larvae feed on flowers and bore into developing fruit causing them to be unmarketable or rendering the fruit susceptible to rot.

Pickleworm is very difficult to predict (or monitor) as eggs are very tiny, moths fly at night but are not attracted to lights, and there is no commercially-available pheromone lure. As a result, cucurbit growers in the South often apply insecticides weekly during the fruiting stages until final harvest. Pyrethroids are often sprayed because of their low cost and efficacy, but, as mentioned previously, they are not IPM compatible and can result in outbreaks of secondary pests such as aphids. Other insecticides that control pickleworm include: the spinosyns, Radiant and Entrust, the diamides, Coragen and Harvanta, the IGR Intrepid, and Avaunt eVo.

With all of the new insecticides registered on vegetables, growers are more confused than ever as to which products control which insect pests. I have done my best in Table 2 to compile the current insecticides registered on cucurbits and rate which of the major insects that they control.

Table 2. Insecticides registered for use on cucurbit vegetables in Virginia (compiled by Tom Kuhar – Virginia Tech)

Product Name (class)	Active Ingredient(s)	Effectiveness rating (E, G, F, P) on pest				PHI (d)	Bee Tox.
		Cucumber beetles	Squash bugs	Aphids	Pickleworm		
Carbamates (1A)							
Lannate LV	methomyl	F	G	G	G	3	H
Sevin XLR	carbaryl	G	G	F	G	3	H
Vydate L	oxamyl	F	F	G	P	1	H
Pyrethroids (3A)							
Asana XL	esfenvalerate	E	E	P	E	3	H
Baythroid XL	beta-cyfluthrin	E	E	P	E	0	H
Bifenthrin 2EC	bifenthrin	E	E	P	E	3	H
Danitol 2.4EC	fenpropathrin	E	E	P	E	7	H
Hero EC	zeta-cypermethrin + bifenthrin	E	E	P	E	3	H
Warrior 2, Lambda-cy	lambda-cyhalothrin	E	E	P	E	1	H
Mustang Maxx	zeta-cypermethrin	E	E	P	E	1	H
Perm-Up 3.2EC	permethrin	E	E	P	E	0	H
Tombstone	cyfluthrin	E	E	P	E	0	H
Neonicotinoids (4A)							
Admire PRO 4.6SC	imidacloprid	E	E	E	P	21	H
Assail 30SG	acetamiprid	G	E	E	P	0	M
Belay 2.13SC	clothianidin	E	E	E	P	21	H
Platinum 75SG	thiamethoxam	E	E	E	P	30	H
Actara 25WDG	thiamethoxam	E	E	E	P	0	H
Scorpion 35SL	dinotefuran	E	E	G	P	1	H
Venom 70SG	dinotefuran	E	E	G	P	1	H
Spinosyns (5)							
Entrust 2SC	spinosad	F	F	P	E	1	M
Radiant SC	spinetoram	F	F	P	E	1	M
Diamides (28)							
Coragen 1.67SC	chlorantraniliprole	F	P	P	E	1	L
Harvanta 50SL	cyclaniliprole	G	E	G	E	1	H
Other selective insecticides							
Intrepid 2F (18)	methoxyfenozide	P	P	P	G	3	L
Avaunt eVo (22A)	indoxacarb	F	F	P	E	3	H
Sivanto 200SL (4D)	flupyradifurone	G	G	E	P	1	M
Fulfill 50WDG (9B)	pymetrozine	P	P	E	P	0	L
Beleaf 50SG (29)	flonicamid	P	F	E	P	0	L

Combo products							
Endigo ZC	lambda-cy + thiamethoxam	E	E	E	E	1	H
Gladiator	zeta-cypermethrin + avermectin	E	E	P	E	7	H
Besiege	lambda-cy. + chlorantraniliprole	E	E	P	E	1	H
Durivo (28+4A)	thiamethoxam+chlorantraniliprole	E	E	E	E	30	H
Minecto Pro (28+6)	cyantraniliprole + abamectin	G	G	G	E	7	H
Voliam flexi (28+4A)	thiamethoxam+chlorantraniliprole	E	E	E	E	1	H

BEST OF THE PENN STATE FLOWER TRIALS 2019

Sinclair Adam
Penn State Extension – Lebanon County
saa19@psu.edu

Achillea 4 cultivars
Best Performance: Milly Rock Rose-DarwinPerennials

Agastache 5 cultivars
Best Performance: POQUITO Butter Yellow-Terra Nova Nurseries
POQUITO Orange-Terra Nova Nurseries

Ajuga 1 cultivar
Best Performance: Princess Nadia-Concept Plants

Alternanthera 1 cultivar
Best Performance: FanciFillers Choco Chili- Westhoff

Angelonia 12 cultivars
Best Performance: Archangel Blue Bicolor-Ball FloraPlant

Archangel Raspberry-Ball FloraPlant
Carita Purple-Syngenta Flowers
Carita White-Syngenta Flowers
Serena Blue-PanAmerican Seed
Serena Rose-PanAmerican Seed
Serena White-PanAmerican Seed
Serenita Sky Blue-PanAmerican Seed
Serenita White-PanAmerican Seed

Argyranthemum-2 cultivars
Best Performance: Percussion Double Lemon-Beekenkamp Plants

Artemesia-1 cultivar
Best Performance: FanciFillers Sea Salt -Westhoff

Begonia-88 cultivars
Best Performance: Big Red Bronze Leaf-Ernst Benary of America
Big Rose Bronze Leaf-Ernst Benary of America
Big Rose Green Leaf-Ernst Benary of America
BK Collection BEEL 3632-Beekenkamp Plants
BK Collection BEEL 4022-Beekenkamp Plants
Crown Jewel Joyful Jasper-J. Berry Nursery

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

Crown Jewel Positively Peridot- J. Berry Nursery
I'CONIA Portofino Citrix-Dummen Orange
I'CONIA Portofino Hot Coral-Dummen Orange
I'CONIA Portofino Hot Orange-Dummen Orange
I'CONIA Portofino Sunrise-Dummen Orange
Move to Fun Orange-Dummen Orange
On Top Sunset Shades-PanAmerican Seed
Prism Rose Shades-Westhoff
Spring Fling Pink Tulip-Ball Ingenuity
Prism Yellow-Westhoff
Prism Velvet Red-Westhoff
Tophat Pink-Syngenta Flowers
Tophat Rose BiColor-Syngenta Flowers
Tophat Scarlet-Syngenta Flowers
Viking Coral Flame on Bronze-Sakata Seed America
Viking Coral Flame on Green-Sakata Seed America
Viking Pink on Chocolate-Sakata Seed America
Viking Pink on Green-Sakata Seed America
Viking Red on Bronze-Sakata Seed America
Viking Red on Green-Sakata Seed America
Viking Rose on Bronze-Sakata Seed America
Viking XL Pink on Green-Sakata Seed America
Viking XL Red on Chocolate-Sakata Seed America
Viking XL Red on Green-Sakata Seed America
Viking XL Rose on Green-Sakata Seed America

Bidens 4 cultivars
Best Performance:
Goldilocks Rocks Improved-Proven Winners
Popstar Red-Kientzler North America
Bee Happy Red Imp. -Ball FloraPlant
Campfire Flame-Proven Winners

Brunnera 2 cultivars
Best Performance:
Sea Heart-Plants Nouveau
Silver Heart-Plants Nouveau

Caladium 2 cultivars
Best Performance:
Fast Flash-Classic Caladiums
Lemon Blush-Classic Caladiums

Calibrachoa 81 cultivars
Best Performance:
Pocket Light Red-Kientzler North America
Pocket Pink-Kientzler North America
Aloha Kona Tiki Soft Pink-Dummen Orange
Aloha Kona White-Dummen Orange
Bloomtastic Serenity-Dummen Orange
Cabaret Diva Orange-Ball FloraPlant
Cabaret Good Night Kiss-Ball FloraPlant

Cabaret Pink Improved-Ball FloraPlant
Cabaret Rose Improved-Ball FloraPlant
Calitastic Ballerina- Westhoff
Calitastic Gold-Westhoff
Calitastic Marooned-Westhoff
Calitastic Papaya-Westhoff
Calitastic Red Lips-Westhoff
Callie Eclipse Raspberry-Syngenta Flowers
Callie Eclipse Strawberry-Syngenta Flowers
Can-Can Bumble Bee Blue-Ball FloraPlant
Can-Can Bumble Bee Pink-Ball FloraPlant
Candy Shop Candy Bouquet Improved-Westhoff
Chameleon Atomic Orange-Westhoff
Chameleon Blueberry Scone-Westhoff
Chameleon Tart Deco-Westhoff
Conga Deep Yellow-Ball FloraPlant
Conga White-Ball FloraPlant
Kabloom Pink-PanAmerican Seed
Kabloom White-PanAmerican Seed
Lia Yellow-Danziger Flower Farm
MiniFamous Lava + Red Eye-Selecta One
MiniFamous Neo Deep Orange-Selecta One
MiniFamous Neo Light Pink-Selecta One
MiniFamous Neo Light Pink + Eye-Selecta One
MiniFamous Neo White + Yellow Eye-Selecta One
MiniFamous Uno Dark Blue-Selecta One
MiniFamous Uno Pink 20-Selecta One
MiniFamous Uno White-Selecta One
Superbells Black Currant Punch-Proven Winners
Superbells Dreamsicle Improved-Proven Winners
Superbells Honeyberry-Proven Winners
Superbells Watermelon Punch-Proven Winners
Superbells Tabletop Blue-Proven Winners
Superbells Tabletop White-Proven Winners
hybrida Cabrio Amethyst-Syngenta Flowers
hybrida Cabrio Eclipse Lilac-Syngenta Flowers
hybrida Cabrio Eclipse Strawberry-Syngenta Flowers
hybrida Cabrio Pink with eye-Syngenta Flowers
hybrida Cabrio Yellow-Syngenta Flowers
MiniFamous Uno Double PlumTastic-Selecta One
MiniFamous Uno Double White Pink Whirl-Selecta One
Superbells Double Orange-Proven Winners

Caryopteris 1 cultivar

Best Performance: Gold Crest-DarwinPerennials

Celosia 13 cultivars

Best Performance:
Kelos Atomic Neon Pink-Beekenkamp Plants
Kelos Fire Orange-Beekenkamp Plants
Kelos Fire Purple-Beekenkamp Plants
Kelos Fire Scarlet Improved=Beekenkamp Plants
Kelos Fire Yellow-Beekenkamp Plants

Coleus 13 cultivars

Best Performance:
Wicked Witch-Proven Winners
FlameThrower Chili Pepper-Ball FloraPlant
FlameThrower Salsa Roja-Ball FloraPlant
FlameThrower Salsa Verde-Ball FloraPlant
FlameThrower Serrano-Ball FloraPlant
Main Street Beale Street-Dummen Orange
Main Street Fifth Avenue-Dummen Orange

Combinations 86 cultivars (43 HB, 43 Pots)

Best Performance:
Blushing Bride-Classic Caladiums
Scarlet Flame-Classic Caladiums
Mom's Chosen One-Syngenta Flowers
Night in Pompeii-Syngenta Flowers
Cabrio Ride Along-Syngenta Flowers
Cabrio Speed Limit Mix-Syngenta Flowers
MixMasters Bloom of Allegiance-Ball FloraPlant
MixMasters Love Me Tender-Ball FloraPlant
MixMasters Peppery Perfection-Ball FloraPlant
MixMasters Porch Patriot-Ball FloraPlant
MixMasters Rainbow Bright-Ball FloraPlant
MixMasters Shindig-Ball FloraPlant
MixMasters Shoot the Breeze-Ball FloraPlant
MixMasters Vindaloo Vision-Ball FloraPlant
Plug & Play Color Carnival-PanAmerican Seed
Plug & Play Firelighter-PanAmerican Seed
Plug & Play Hocus Pocus-PanAmerican Seed
Plug & Play XXL Date Knight-PanAmerican Seed
Plug & Play XXL Feeling Frisky-PanAmerican Seed
Plug & Play XXL Summer Lovin-PanAmerican Seed
Woodland 4 Season A-Kientzler North America

Cuphea 3 cultivars

Best Performance:
Honeybells- Ball FloraPlant
Floriglory Corazon-Westhoff
Floriglory Diana-Westhoff

Dahlia 42 cultivars

Best Performance:
City Lights Lavender Pink-Selecta One
City Lights Purple-Selecta One
Hypnotica White-Dummen Orange

LaBella Maggiore DAXX 3639-Beekenkamp Plants
LaBella Maggiore Purple-Beekenkamp Plants
LaBella Maggiore Yellow Improved-Beekenkamp Plants
Temptation Lavender-Dummen Orange
Venti Royal Purple-Selecta One

Delosperma 10 cultivars
Best Performance:
Solstice Rose-Dummen Orange
Solstice Yellow-Dummen Orange
Wow Purple-Concept Plants
Wow Salmony Pink-Concept Plants

Dendranthema 6 cultivars
Best Performance:
Brilliant Igloo-Must Have Perennials
Ice Pink Igloo-Must Have Perennials
Dainty Pink Igloo-Must Have Perennials

Dianthus 15 cultivars
Best Performance:
Vivid Bright Lights-Concept Plants

Dideltia 1 cultivar
Best Performance:
FanciFillers Silver Strand-Westhoff

Digitalis 2 cultivars
Best Performance:
Pink Panther-American Takii
Arctic Fox Rose-DarwinPerennials

Echinacea 12 culivars
Best Performance:
Green Twister-Jelitto Perennials
Sombrero Granada Gold-DarwinPerennials
Cara Mia-Terra Nova Nurseries

Euphorbia 2 cultivars
Best Performance:
Diamond Snow-Proven Winners
Glamour Improved-PanAmerican Seed

Fern 15 cultivars
Best Performance:
Arachniodes Shiny Bristle Fern-Casa Flora
Dryopteris erythrosora Brilliance-Casa Flora
Dryopteris filix mas Parsley Male Fern-Casa Flora
Dryopteris pulcherrima Beautiful Wood Fern-Casa Flora
Dryopteris tokyoensis Tokyo Wood Fern-Casa Flora
Dryopteris x australis Dixie Wood Fern-Casa Flora
Polystichum x dycei Dyce's Wood Fern-Casa Flora

Fescue 1 cultivar
Beyond Blue-Concept Plants

Gaillardia 6 cultivars
Best Performance:
Spintop Red-Dummen Orange
Heat it Up Scarlet-Proven Winners
Heat it Up Yellow-Proven Winners

Gaura 3 cultivars
Best Performance: Graceful White-Dummen Orange

Geranium Hardy 3 cultivars
Best Performance: B150B536-Must Have Perennials
Bloom Time-Cultivaris

IS 8 cultivars
Best Performance: Big EEZE Fuchsia Blue-Dummen Orange
Big EEZE Pink-Dummen Orange

IS 8 cultivars: Calliope Large Coral-Syngenta Flowers
Calliope Large Dark Red-Syngenta Flowers
Calliope Large Orange Splash-Syngenta Flowers

Zonal 13 cultivars
Best Performance: Super Moon Red-Selecta One
Dynamo Orange-Ball FloraPlant
Dynamo Pink Flare-Ball FloraPlant
Dynamo Red Improved-Ball FloraPlant
Galaxy Pink-Ball FloraPlant
Galaxy Violet-Ball FloraPlant
Galaxy White-Ball FloraPlant

Gerbera 10 cultivars
Best Performance: ColorBloom Yellow with Dark Eye-PanAmerican Seed
Garvinea Sweet Fiesta-Florist Holland
Garvinea Sweet Glow-Florist Holland
Garvinea Sweet Memories-Florist Holland
Garvinea Sweet Sunset-Florist Holland

Geum 2 cultivars
Best Performance: Tempo Yellow-Terra Nova Nurseries

Helenium 1 cultivar
Best Performance: Mariachi Sombrero-Plants Nouveau

Helianthus 1 cultivar
Best performance: H. salicifolius Autumn Gold-DarwinPerennials

Helichrysum 4 cultivars
Best Performance: Silver Ribbon-Selecta One
Silver Stitch-Selecta One
Silver Threads-Selecta One
FanciFillers Silverstar-Westhoff

Heuchera 8 cultivars
Best Performance: Northern Exposure Lime-Terra Nova Nurseries
Northern Exposure Silver-Terra Nova Nurseries
Northern Exposure Black-Terra Nova Nurseries
Northern Exposure Purple-Terra Nova Nurseries
Dolce Wildberry-Walters Gardens

Hibiscus 3 cultivars

Best Performance: Summerific Evening Rose-Walters Gardens

Impatiens 69 cultivars

Best Performance:
w. Beacon Bright Red-PanAmerican Seed
w. Beacon Coral-PanAmerican Seed
w. Beacon Orange-PanAmerican Seed
w. Beacon Salmon-PanAmerican Seed
w. Beacon Violet Shades-Pan American Seed
w. Beacon White-PanAmerican Seed
w. Imara XDR Rose-Syngenta Flowers
w. Imara XDR Salmon Shades-Syngenta Flowers
SunPatiens Compact Orchid Blush-Sakata Seed America
SunPatiens Vigorous Orchid-Sakata Seed America
SunPatiens Vigorous Red-Sakata Seed America
SunPatiens Vigorous Rose Pink-Sakata Seed America
SunPatiens Vigorous Shell Pink-Sakata Seed America
ColorPower Magenta Frost-Selecta One
ColorPower Orchid Flame-Selecta One
ColorPower White-Selecta One
Paradise Electric Orange-Kientzler North America
Paradise Peach-Kientzler North America
SunStanding Apollo Cherry Red-Dummen Orange
SunStanding Apollo Lavender-Dummen Orange
SunStanding Apollo Neon Rose-Dummen Orange
SunStanding Apollo Orange-Dummen Orange
SunStanding Apollo Purple-Dummen Orange
SunStanding Apollo Ruby Red-Dummen Orange
SunStanding Apollo White Cloud-Dummen Orange
SunStanding Helios Coral Aurora-Dummen Orange
SunStanding Helios Flame Orange-Dummen Orange
SunStanding Helios Magenta-Dummen Orange
SunStanding Helios Magenta Borealis-Dummen Orange
SunStanding Helios Neon Red-Dummen Orange
SunStanding Helios Spot-on Lavender-Dummen Orange
SunStanding Helios Spot-on Pink Blush-Dummen Orange

Ipomoea 6 cultivars

Best Performance: Spotlight Red-Ball FloraPlant

Sweet Caroline Red Hawk-Proven Winners

Lantana 28 cultivars

Best Performance:
Bandana Mango-Syngenta Flowers
Bandana Orange-Syngenta Flowers
Bandana Pink Improved-Syngenta Flowers
Bandana Rose-Syngenta Flowers
Bandana Yellow Improved-Syngenta Flowers

Bandolera Cherry Sunrise-Syngenta Flowers
Bandolera Guava-Syngenta Flowers
Bandolera Pineapple-Syngenta Flowers
Bandolera Red-Syngenta Flowers
Bandolera White-Syngenta Flowers
Bloomify Mango-Ball FloraPlant
Bloomify Red-Ball FloraPlant
Bloomify Rose-Ball FloraPlant
Havana Full Moon-Dummen Orange
Havana Gold-Dummen Orange
Havana Sunrise-Dummen Orange
Havana Sunset-Dummen Orange
Havana Sunshine-Dummen Orange
Hot Blooded Red-Syngenta Flowers
Landscape Bandana Lemon Zest Improved-Syngenta Flowers
Lucky Peach-Ball FloraPlant
Lucky Pot of Gold-Ball FloraPlant
Lucky Red-Ball FloraPlant
Luscious Goldengate-Proven Winners

Lobularia 3 cultivars
Best performance: Easy Breezy Pink-Ball FloraPlant
Easy Breezy Purple-Ball FloraPlant
Easy Breezy White-Ball FloraPlant

Lychnis 2 cultivars
Best Performance: Petite Jenny-Must Have Perennials

Lysimachia 2 cultivars
Best Performance: FanciFillers Sunburst-Westhoff

Miscanthus 1 cultivar
Best Performance: Bandwidth-Darwin Perennials

Nemesia 7 cultivars
Best Performance: Aromance Pink-Proven Winners

Ornamental Pepper 2 cultivars
Best Performance: Red Onyx-PanAmerican Seed

Osteospermum 11 cultivars
Best Performance: Bright Lights Purple-Proven Winners
Bright Lights White-Proven Winners
Sunny Harmony-Beekenkamp Plants

Pennisetum 2 cultivars

Best Performance:	Lumen Gold-Concept Plants
	Yellow Ribbons-Intrinsic Perennial Gardens

Penstemon 3 cultivars

Best Performance:	DAKOTA Burgundy-Terra Nova Nurseries
	DAKOTA Verde-Terra Nova Nurseries
	Quartz Red-DarwinPerennials

Pentas 15 cultivars

Best Performance:	BeeBright Lipstick-Syngenta Flowers
	BeeBright Pink-Syngenta Flowers
	BeeBright White-Syngenta Flowers
	Graffiti 20/20 Flirty Pink-Benary
	Lucky Star Lavender-PanAmerican Seed
	Lucky Star Lipstick-PanAmerican Seed
	Lucky Star Violet-PanAmerican Seed
	Lucky Star White Improved-PanAmerican Seed
	Sunstar Lavender-Proven Winners
	Sunstar Rose-Proven Winners

Petchoa 2 cultivars

Best Performance:	SuperCal Snowberry White-Sakata Seed America

Petunia 64 cultivars

Best Performance:	Midnight Gold-Ball FloraPlant
	Tea Purple Vein-Beekenkamp Plants
	Tea Rose Morn-Beekenkamp Plants
	Tea White-Beekenkamp Plants
	ColorRush Blue-Ball FloraPlant
	ColorRush Merlot Star-Ball FloraPlant
	ColorRush Pink-Ball FloraPlant
	ColorRush White-Ball FloraPlant
	Supertunia Vista Snowdrift-Proven Winners
	Supertunia Raspberry Rush-Proven Winners
	Supertunia Sharon-Proven Winners
	Supertunia Mini Vista Indigo Improved-Proven Winners
	Trilogy Lime-American Takii
	Trilogy TX-931 Pink Lip-American Takii
	Wave Carmine Velour-PanAmerican Seed
	Wave Misty Lilac-PanAmerican Seed
	Wave Purple-PanAmerican Seed
	Veranda Compact Double Lavender-Kientzler North America
	Veranda Compact Double Rose Pink-Kientzler North America
	Veranda Compact Double Sugar Plum-Kientzler North America
Petunia Honorable Mention:	Tea Purple Vein-Beekenkamp Plants
	Crazytunia Berry Frappe-Westhoff
	Crazytunia Black Mamba-Westhoff

Crazytunia Spider Girl-Westhoff
Dekko Blue Improved-Syngenta Flowers
Dekko Red-Syngenta Flowers
Supertunia Vista Snowdrift-Proven Winners
Wave Carmine Velour-PanAmerican See

Phlox 13 cultivars
Best Performance: Bambini Desire-Concept Plants

Portulaca 8 cultivars
Best Performance: Campino Twist Red-Danziger Flower Farm
Mojave Red Improved-Proven Winners
Pazzaz Apricot-Danziger Flower Farm
Pazzaz Bright Purple-Danziger Flower Farm

Rudbeckia 8 cultivars
Best Performance: SmileZ Glowing-Plants Nouveau
SmileZ Sunny-Plants Nouveau
Glitters Like Gold-Intrinsic Perennial Gardens
American Gold Rush-Intrinsic Perennial Gardens
Blackjack Gold-Jelitto Perennials

Salvia 31 cultivars
Best Performance: Salvia Purple-HilverdaKooij
Salvia Red-HilverdaKooij
Rockin' Blue Suede Shoes-
Skyscraper Dark Purple-Selecta One
Skyscraper Orange-Selecta One
Skyscraper Pink-Selecta One
Mystic Spires-Ball FloraPlant
Mysty-Ball FloraPlant
Icon Dark Blue-Dummen Orange
Icon Light Blue-Dummen Orange
Icon Violet-Dummen Orange
Unplugged So Blue-Proven Winners

Scaevola 7 cultivars
Best Performance: Scalora Brilliant- Westhoff
Scalora Pearl-Westhoff
Surdiva Blue Violet-Suntory Flowers
Surdiva Sky Blue-Suntory Flowers
Surdiva White Improved-Suntory Flowers
Whirlwind Blue Improved-Proven Winners

Sedum 4 cultivars
Best Performance: Chocolate Cherry-Cultivaris
Peace and Joy-Intrinsic Perennial Gardens

Stokesia 2 cultivars

Best Performance:	Mel's Blue-Plants Nouveau

Sutera 5 cultivars

Best Performance:	Snowstorm Glacier Blue-Proven Winners
	Snowstorm Pink-Proven Winners
	Snowstorm Snow Globe Improved-Proven Winners

Verbena 30 cultivars

Best Performance:	Cadet Upright Hot Pink Wink-Ball FloraPlant
	Cadet Upright Lavender Blue-Ball FloraPlant
	Cadet Upright Violet Blue-Ball FloraPlant
	Firehouse Grape-Ball FloraPlant
	Firehouse Light Pink-Ball FloraPlant
	Firehouse Pink-Ball FloraPlant
	Firehouse Red-Ball FloraPlant
	Lascar Mango Orange-Selecta One
	Lascar Vampire-Selecta One
	Superbena Sparkling Amethyst-Proven Winners
	Vanessa Purple-Danziger Flower Farm
	Vanessa White Improved-Danziger Flower Farm

Vinca 14 cultivars

Best Performance:	Cora Red-Syngenta Flowers
	Cora XDR Hotgenta-Syngenta Flowers
	Cora XDR Pink Halo-Syngenta Flowers
	Cora XDR White-Syngenta Flowers
	Soiree Ka-wa-i-i Coral-Suntory Flowers
	Soiree Ka-wa-i-I Lavender Suntory Flowers
	Soiree Ka-wa-i-I White Peppermint-Suntory Flowers

Zinnia 9 cultivars

Best Performance:	Profusion Cherry Bicolor-Sakata Seed America
	Zesty Pink-Ball Ingenuity
	Zesty Scarlet-Ball Ingenuity
	Zesty Yellow-Ball Ingenuity

TISSUE CULTURE FINISHING FOR GREENHOUSE GROWERS

Sinclair Adam
Penn State Extension – Lebanon County
saa19@psu.edu

In the past 25 years a great development has occurred in tissue culture plant production for horticulture, and today it is possible to purchase from a number of laboratories stage III tissue culture plantlets that are grown through stage IV in greenhouses. The improvements in this process result in good uniform crops that are essentially disease free when arriving at the greenhouse operation. The plantlets can come from anywhere on the globe and pass through phytosanitary inspections readily due to their being cultured in a sterile medium. This also gives a grower a choice of source (or sources) to improve year-round product availability and provide some degree of competition in costs. A wide range of plants are available from this type of propagation today, and tissue culture (tc), has made new plant selections and hybrids more rapidly available to greenhouse growers than in the past.

If you have not tried tc finishing in your operation you may wish to consider the differences from unrooted cuttings and seed propagation before investing in tissue cultured plantlets. Stage III plantlets arrive with roots, and leaves established on the plantlet but the plantlet is not acclimated to the 'real world'.

Some environmental and managerial considerations for tissue culture finishing are paramount for success. A mist or fog system is required, good temperature control, light control (both day length & intensity), and good technical skill. These plantlets are not the same as unrooted cuttings in that they were grown in a sealed vessel, and do not operate as would an unrooted cutting from a stock plant grown in a greenhouse. They are not photosynthesizing properly, their stomata are not operating as would an acclimatized plant, the leaf cuticle is missing or poorly formed, and the roots are also not functioning as would an acclimatized plant. Further the tc plantlets typically were in an environment of 75-80 degrees F, with a 16-hour day length, before being shipped to the grower. To meet the needs of these plantlets, mist should be used for 1-3 weeks while the plantlet grows new leaf tissue and some new roots. The temperature can be slowly adjusted in the greenhouse from the lab temperature to the normal cropping temperature for that particular plant. Perennial plants such as Echinacea, Heuchera, and Tiarella grow satisfactorily at cooler temperatures than annual plant species and can be established from tc plantlets in 58-68 degrees F, while the annual plants are going to develop better from tc plantlets with a 68-78 degrees F environment. Regardless, both groups will need to be acclimated to the target temperature range, and not merely dropped into that temperature. New leaves produced while being misted, will grow the proper cuticle for protection, and stomata will be operational. Root tissue grown ex-vitro will be functioning properly. Light should be reduced in intensity, especially from May to September, as the lab was probably growing the plantlets under fluorescent lamps. The daylength should be increased to 14-16 hours of light, during short days, and then can be reduced as the tc plantlets acclimate to the real world. This can be done with a number of different lamp types successfully. If a species (or cultivar) is triggered for growth under long days, then that is what it should receive in the propagation period at the greenhouse. After the plant has finished in the mist system the day length can be reduced to the natural period. If you are doing this production in the late fall or winter, the perennial plants may go into dormancy with reduced day length.

Crop timing will vary by operation, and by environment, but the perennials started from tc will typically take 5-8 weeks to finish as plugs. Some species will take longer. Rapidly growing species could finish in less time with opti-

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

mum light levels, and temperatures. An important consideration in success is the planting depth of the tc plantlet. It should be placed in the rooting medium at crown height, and plantlets that are too high will dry out while plantlets inserted too deeply into the medium will be likely to rot. On some species this is a very small difference between too low (or too high) and just right, perhaps as little as 1/8th inch. Plant propagators who do not pay strict attention to the height the microcuttings are inserted in the medium can expect crop losses. Good attention should be paid to medium to plantlet contact. A plantlet that is poorly seated in the medium can also dry out. Mist frequency and mist duration will vary by greenhouse environment, but the foliage should not get dry during the daylight period until the new leaves have been formed. The mist schedule should be set to re-mist the flats of plants just as the foliage begins to dry. A successful schedule on a sunny day in spring is 10 minutes between mistings and 20 seconds of mist on time, but this should be tested and altered to suit the growing environment in question. By early summer the interval between misting cycles may have dropped to 8 minutes, and on cloudy days will probably need to be extended to 15-20 minutes between misting cycles. On a very rainy day, frequency could be 20-40 minutes between cycles. Regardless of time of year and cloud cover the principal is the same, do not let the foliage get dry on the leaf surface. A leaf without cuticle is very easy to dry out (permanently). Growers new to tc finishing should expect to observe the crop frequently until they are more familiar with the crop needs and performance in their system. Once the microcuttings have grown some new tissue they can be weaned off the mist, but again this should be done gradually, not radically for successful acclimation.

It is often required that plants need to be sized after the misting period has been concluded. Tissue culture producers generally do a good job in their part of propagation, but some variance in plantlet size is inevitable. While a propagator receiving the tc plantlets can size them before planting in flats, the operation is likely to need to do some sizing after the crop has completed the misting phase. By grouping the large plants, the medium, and the small in different flats there will be less total crop losses. It is very inefficient to water plug by plug, so size them and water by flat. Once the misting phase is completed, you now have a successful stage IV plant, which means it is truly acclimated. Plugs finished from tc plantlets may require a week or two more growing time before shipment, so as to be well rooted into the plug tray, but they are basically ready for sale or potting up.

Problems encountered with tissue culture shipments could include biological contamination with bacteria, fungi, and possibly virus (although this is very rare). By inspecting the shipment carefully upon receiving and contacting the supplier with photos and unit counts that are contaminated a claim or adjustment should be given by the supplier. Another potential problem is environmental damage. This can occur if temperatures during shipment have not been met, or if hyperhydracity has occurred. This is a condition where the tissue is excessively hydrated and the tissue is malformed. It occurs as a physiological malformation and is caused by oxidative stress often from too high levels of salts in the media, too high relative humidity, too low light intensity, or other mismanagement of the vessel in the lab. If a greenhouse operation receives tissue culture plants suffering from this issue the plants should be claimed. Tissue culture plants can turn brown due to oxidation of phenols within the plant tissue. These plants should also be claimed and credited by the lab.

Managing tissue cultured plants can be a bit challenging especially for the grower just getting into the process. Working closely with the supplying lab (or labs) is paramount for success with this form of propagation. Closely monitoring post-lab greenhouse production is equally important for success. Therefore, managing mist, irrigation, light, temperature, and relative humidity must be carefully done and adjusted as needed to the changing environmental conditions. With careful attention to these requirements will yield success with this type of propagation.

HABITAT PLANTS TO SUPPORT BENEFICIALS IN HIGH TUNNELS: THE BEST THINGS IN LIFE ARE FREE

Margaret Skinner, Research Professor and Extension Entomologist
Cheryl Frank Sullivan, Research Technician
University of Vermont, Entomology Research Laboratory
661 Spear Street, Burlington, VT 05405-0105
Email: mskinner@uvm.edu, cfrank@uvm.edu

Elsa Sánchez, Professor of Horticultural Systems Management
The Pennsylvania State University, Department of Plant Science
202 Tyson Building, University Park, PA 16802
Email: ess11@ag.psu.edu

To generate greater revenues and better serve their customers with local produce, growers in the Northeast and Mid-Atlantic states are extending their vegetable growing season with high tunnels. High tunnels are fairly rudimentary hoop houses covered with one or two layers of plastic, vented with roll-up sides for cooling in warm weather, and often lack electricity or heating. Scientists from the University of Vermont and Penn State University collaborated on a project to assess the use of **habitat plants** in high tunnels. These plants are grown within the crop production area specifically to provide shelter and food (nectar and pollen) for beneficials. They attract and support naturally-occurring biological control agents and pollinators coming from outside the high tunnel. In addition, they can also attract the pest, so they serve as an early detection system. Growers who release natural enemies in their high tunnels often put them on the habitat plants to ensure they have a food source should there be no pests in the crop. Biological control works best when done proactively, and habitat plants are a cost-effective way to get it going early.

How do Habitat Plants Work? Many flowering plants are attractive to pests and beneficials, but not all of them are good habitat plants. We tested several types of plants in the summer for tomatoes and in winter for leafy greens. Over 3 years, we evaluated alyssum, green bean, marigolds, borage, calendula, viola and dill for the summer season; alyssum, green beans, marigolds, calendula and viola for the winter. We assessed several factors that should be considered when selecting a suitable plant as a habitat plant, including its ability to produce flowers over a long period with pollen and nectar, its tolerance to heat or cold temperatures, its ease of production and its attractiveness to the target pest and beneficials. Clumps of these plants were grown at the front and back of each crop row in high tunnels, and connected to the drip irrigation system used for the crop. We quickly learned that growers didn't want to bother with watering them by hand. When possible, the flowering plants were started in a heated greenhouse in a cage to prevent them from becoming infested with pests before they were placed in the high tunnels. When possible, plants were placed in the high tunnels before the crop was added. This allowed resident pests to be attracted to the habitat plants rather than the crop. Growers were encouraged to scout the habitat plants for pests

Fig. 1. Habitat plants (alyssum, borage, beans) in tomatoes.

Dr. Margaret Skinner is a Research Professor and Extension Entomologist at the Univ. of Vermont, Entomology Research Lab, where she has worked for 36 years, conducting research on management of a wide array of insect pests in forests, vegetables and greenhouse ornamentals. Her current primary target pests are aphids in high-tunnel vegetables and western flower thrips in greenhouse ornamentals. She works on developing strategies to maximize the potential of insect-killing fungi and plant-mediated systems. As the UVM Extension Entomologist she assists professional growers and homeowners with pest id and IPM.

and release the appropriate natural enemy for the pests. If pest populations became high on the habitat plants over the season, growers were advised to bag and remove the plants and replace them with fresh uninfested plants.

Fig. 2. Syrphid (hover fly) adult on alyssum (top), larva (bottom) feeding on aphids.

Natural enemies were observed on 89% of the inspected habitat plants over the study period, during the summer seasons and 60% during the winter season. A wide range of insects were observed on the habitat plants, including parasitic wasps and their aphid mummies, adult syrphid flies (Fig. 2) and adult and immature insidious pirate bugs (Orius). Other predators were also observed, including, lacewings, assassin bugs, spiders and various lady beetle in different life stages. The greatest abundance and diversity of natural enemies were observed on alyssum, borage, calendula and dill. Alyssum had the greatest tolerance to high heat and cold. It flowered throughout most of the growing season, and was non-invasive. It was easy to grow and care for and was the least attractive to aphids among the plants we tested. Borage and calendula, although attractive to natural enemies, were susceptible to aphid infestations. In addition, borage tended to become too large, outcompeting other plants and the crop. It also readily self-seeded, turning it into a weed. Calendula took a long time to flower. Our results suggest **alyssum** may be a particularly suitable habitat plant for attracting and sustaining natural enemies for year-round high tunnel production. We encourage growers to try growing this plant to attract and support beneficial insects. For additional information go to our UVM Entomology Research Laboratory website:

https://www.uvm.edu/~entlab/

Research reported herein was supported by the Northeast Sustainable Agric. Research & Education Program (#LNE15-343); USDA, NIFA, Crop Protection & Pest Management Competitive Grants Prog. (#2014-70006-22516) and Extension IPM Program (#2014-70006-22577); and the Univ. of Vermont Extension System. Any opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily reflect the view of the US Dept. of Agriculture.

SAFFRON: A HIGH VALUE CROP FOR INCREASING FARM REVENUES

Arash Ghalehgolabbehbahani, Margaret Skinner and Bruce L. Parker
University of Vermont
North American Center for Saffron Research and Development
661 Spear Street, Burlington, VT 05405-0105
Email: aghalego@uvm.edu Website: http://www.uvm.edu/~saffron/

Over 95% of Northeastern farms are ranked "small" by USDA, grossing less than $350,000 annually. Crop diversification is key to their viability. SAFFRON—the stigmas of a fall-blooming crocus, and the world's most expensive spice (over $5,000/lb.)—could strengthen the economic security of small farms (Fig. 1). Since 2015, over 2,000 growers have expressed interest in saffron production, and 75% are growing it now. The US market revenue from imported product was estimated at over $60 million in 2018, demonstrating the potential demand for locally-grown saffron. It is commonly used as a culinary spice in ethnic cuisines, but also is reported to have medicinal properties, increasing its value above other herbs and spices. In 2016, the US was the 3rd largest saffron importer, bringing in over 45 tons. University of Vermont researchers have shown that saffron can be grown successfully in the field and in high tunnels in the colder regions of the Northeast. The potential to supply US markets with locally-produced saffron could strengthen economic security for small diversified nationwide farmers. Corms remain in the ground for 3-6 years, increasing in density and saffron yield annually. Though labor costs to pick/process saffron are high, they are not more than for high-tunnel tomatoes, a widespread Northeastern crop. Mechanical saffron harvesting/processing equipment is under development to reduce labor expenses and luckily saffron harvesting occurs for 2-4 weeks in October-November when field work demands are less. The USDA doesn't collect data on saffron production but one major supplier sold >200,000 corms to US growers (new and established growers) in 2019, equivalent to over one acre of new saffron production. In a 2019 survey of 550 Saffronnet subscribers, 75% intend to harvest saffron in 2019 and 90% by 2020.

Fig. 1. Saffron flower. Arrow points to the stigmas.

Fig. 2. High tunnel production of saffron in Vermont, Brian Leven, Stowe, VT, grows it in raised beds in high tunnels (Photo by G. Miller, Stowe Today).

Though saffron is suitable for a wide range of growers, the most likely ones are vegetable farmers and nursery/floriculture producers. It is an emerging crop, and US growers report selling their product for between $20-75 per gram (equivalent to $9,000-34,000/lb). In a good year, a grower should be able to harvest around 5-12 lb/acre within 3 years of establishing their saffron beds. Skeptics question the marketability of saffron, but given the strong locavore movement, US saffron could compete for a share of this market. To develop a viable market for saffron, it is essential that growers have enough high-quality product to satisfy the demand. The first step is to refine production methods to maximize on yield. We have been working at the Univ. of Vermont since 2015 on several aspects of saffron production. Due to concerns that saffron might not survive the cold winter temperatures in Vermont we initially fo-

Arash Ghalegolabbehbahani is a Postdoctoral Research Associate at the University of Vermont (UVM). He started work on saffron in Vermont in 2015, where he co-founded the North American Center for Saffron Research & Development. He has conducted much of UVM's field research on growing saffron in cold climates, and works with growers to refine and improve their production and processing practices. Prior to coming to the US, he was a research assistant in Iran, working on crop diversity, and served as an inspector for a German organic certifying company. He received his Ph.D. in Agroecology from Ferdowsi University of Mashhad, Iran in 2015.

cused on growing it in high tunnels (Fig. 2). Because many growers use their high tunnels for tomatoes, we developed a system of growing saffron in milk crates which could be moved out in the spring. This would allow growers to maximize on their tunnel space with two high value crops. Our results over two years showed that saffron yields were greater in crates than in ground (in raised beds) and yield increased in the second year (Fig. 3). Rodent damage was a major pest issue for the in-ground plantings.

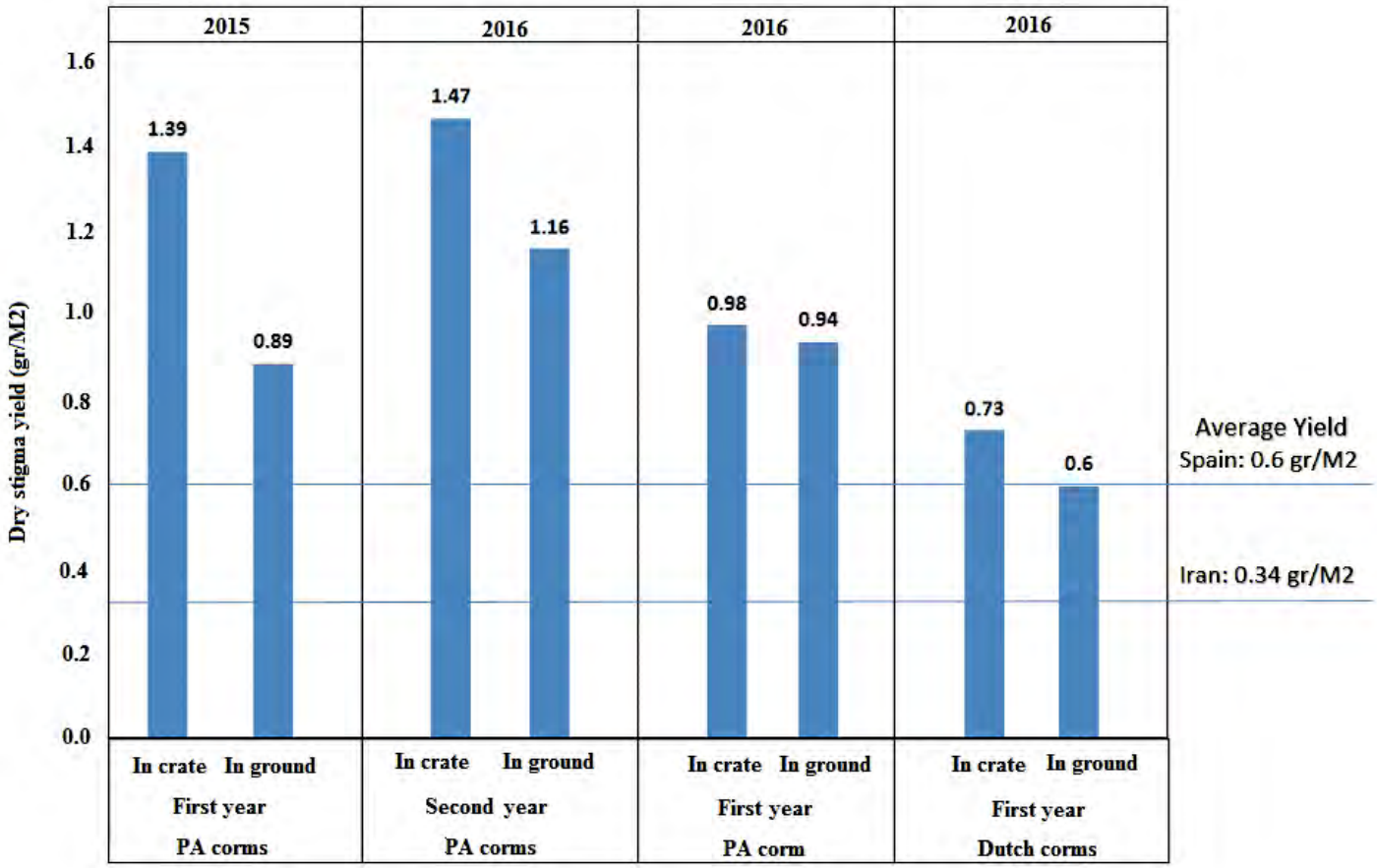


Fig. 3. Saffron yield when grown in crates or in ground (raised beds) over 2 years

The key to cost-effective saffron cultivation is to promote secondary corm production. We found that the number of corms almost doubled from Year 1 to 2 in the crate treatment (Table 1). The number of corms declined in Year 2 for the in-ground treatment as a result of rodent feeding.in-ground treatment as a result of rodent feedingTable 1. Corm production in the ground and in crates.

Table 1. Corm production in the ground and in crates

Treatment	# Primary corms 2015	# Secondary corms 2016	Average Wt/corm 2015 (gr)	Average wt/corm 2016 (gr)
In ground	465	407	11.2	10.3
In crates	465	756	11.2	7.7
Note: We have since observed 3 or more corms developing from a single corm 1 year after planting in the field.				

Because some growers prefer to grow in the field rather than in high tunnels, we are finishing up a 2-year study to assess the suitability of growing saffron outside in different coldhardiness zones in Vermont (Zone 4a, 4b, and 5a) (Fig. 4). We have found that saffron thrives in these three zones. The greatest issues growers have faced are weed control, rodent damage and poorly-drained soil. Because saffron corms stay in the same growing bed for 4-6 years, it is essential that weeds are eliminated before the corms are planted. We experimented with covering the saffron beds with weed cloth over the summer and that reduced weed pressure. It is important to remove the weed cloth in

August before the saffron begins to sprout. This may not be suitable for areas where summer temperatures are particularly high.

Fig. 4. Field production of saffron by Patti and John Padua in Monkton, VT, Zone 4b.

We learned firsthand that planting saffron in heavy clay soils which are poorly drained can be a problem. Water-logged soil in the spring can lead to corm rot and infestations of bulb mites.

There is much to be learned to refine and perfect saffron production in the diverse conditions found in Northeast and across the US. Every year more growers are trying saffron for the first time. These innovative producers are leading the way for this emerging industry, which will hopefully result in enhanced revenues for diversified growers of all types

Research reported herein was supported by the Univ. of VT College of Agriculture & Life Sciences; Peck Electric; Roco Saffron and the VT Agency of Agric. Specialty Crops Block Grant. Any opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily reflect the view of the US Dept. of Agriculture or other funding organizations.

INFLUENCE OF COVER CROPS ON ALLIUM LEAF MINER IN ONION

Gladis Zinati
Rodale Institute, 611 Siegfriedale Road, Kutztown, PA19530
Email: gladis.zinati@rodaleinstitute.org

Allium Leaf miner (Phytomyza gymnostoma); ALM, is an invasive pest that infests plants in the allium species such as: onion, garlic, chives and leeks. Its presence was first confirmed in Lancaster, PA in 2015, and other counties such as Lehigh, Berks, Chester and Dauphin in 2016. Currently, reports confirmed ALM on allium crops in Maryland, New Jersey, New York and Massachusetts.

The ALM adults emerge in spring and feed on allium leaf tissue exudates. The ALM adult female punctures leaves in linear pattern and lays its eggs. The larvae tunnel the leaves from inside, moving down to the bulb or leaf sheaths where they pupate. The larvae feeds on allium bulb tissue and feeding areas become soft and exposed to mold and rotting. After a resting period in the summer, the pupae emerge again as adults in September or October, representing the second generation. Organic growers have been experiencing reductions in yields of allium crops and marketability due to this pest.

In Pennsylvania, sales of certified organic onion and garlic are $373,852 and $321,469, respectively. Unlike conventional growers, organic allium growers have limited options to registered organic pesticides for controlling or reducing the ALM pest impact. Organic allium growers have been interested in viable management options of the ALM pest that does not depend merely on pesticides.

At Rodale Institute, a research project was established in 2017 over two years to investigate the impact of cover crop mixtures, bed cover, and row cover duration on yellow onion yield, ALM, and pungency. Two main cover crop mixtures were used in the fall of each year: 1) mycorrhizal-associated and 2) non-mycorrhizal-associated cover crop mixtures. The mycorrhizal-associated cover crops included hairy vetch, cereal rye, sunflower, white Dutch clover (referred to as Myco treatment), whereas, the non-mycorrhizal-associated cover crops included brassica seed mixture represented by mustard, rape, and tillage radish brassica plants (referred to as brassica (BR) treatment). Seedlings of each of Cortland, Sedona and Talon yellow onion varieties were planted in bare ground and on three different plastic covered beds (black, silver reflective, and red). The seedlings were covered with row cover for a period of 0, 1 and 1.5 months.

Seedlings were monitored for four weeks for ALM injury on leaves and tagged accordingly. Also, yellow and blue sticky cards were used to assess the emergence and counts of ALM on colored sticky cards. Harvested onion bulbs were cured for three weeks and subsampled for mineral nutrients at the Pennsylvania State University AASL and for pungency at Purdue University.

Results and recommendations:

- The use of row cover to cover onion seedlings at time of planting for 1 month was effective and optimal to reduce ALM injury when compared to no cover. Thus row covers can be considered a viable tool to reduce ALM injury and improve marketability of onion yields.
- The adult ALM was attracted to yellow sticky cards than to blue one. Thus, yellow traps can be useful for early detection of ALM adults in spring and for emergence of second generation ALM adults in late summer.

Gladis Zinati is a director of the Vegetable Systems Trial at Rodale Institute, Kutztown, PA. Dr. Zinati research focuses on the development of strategies to optimize soil health, weed and insect pest management in organic crop production. These strategies include compost formulations, cover crops, reduced tillage, and natural habitats. She has a set of undergraduate degrees in General Agriculture and Agriculture Engineering and MSc. degree in Horticulture from the American University of Beirut, Beirut, Lebanon. Her Ph.D. is in Soil Fertility from Michigan State University, E. Lansing, MI. She has 24 peer-reviewed publications and 39 proceedings and outreach educational publications, and experienced in giving scientific and educational presentations and hands-on workshops.

- Sedona and Cortland onion plants that were not protected by row cover and were grown on bare ground in the Myco treatment were affected by the ALM. The plants showed series of linear punctures on the leaves. A week later, only Cortland plants that were not covered with row cover and grown in the bare ground in the BR treatment were only affected by ALM. When they plants were checked again at harvest for presence of larvae or pupae, only two plants were showing larvae.
- Only one Cortland plant grown on black plastic in one replicate showed ALM injury on the leaves.
- All onion varieties that were grown in red plastic had lower yields than those on reflective plastic mulch. Onion yields of Sedona variety were 25% greater when grown in beds covered with black plastic much in the BR treatment than in the Myco.
- Sedona onion yield increased by 45% when covered with 1-month row cover and grown on reflective silver plastic mulch and by 25% when grown on beds with black plastic mulch in the BR treatment when compared to no cover.
- Pungency level varied with variety and it was greatest in Cortland followed by Talon and Sedona when grown on bare ground. On plastic mulch pungency level varied with plastic over, cover crop treatment and variety. It was higher in plants grown in the BR treatment than in the Myco treatment.

This research was supported in part by a grant from the Pennsylvania Vegetable Marketing and Research Program and the Pennsylvania Vegetable Growers Association.

REDUCED TILLAGE IN WINTER SQUASH: EFFECTS ON POST-HARVEST NUTRIENT QUALITY

Gladis Zinati
Rodale Institute, 611 Siegfriedale Road, Kutztown, PA 19530
Email: gladis.zinati@rodaleinstitute.org

The 'Waltham' winter squash, (Cucurbita moschata Duch.), is a popular variety of butternut squash, and valued for its nutritional quality and flesh color. The intensity of the orange flesh color is related to total carotenoid content, important phytonutrients. Winter squash is also known for being a good nutritional source of minerals (potassium, phosphorus, calcium, magnesium, iron and selenium), vitamins (C, E, K, B1, B2, and B6), dietary fiber, and phenolic compounds (flavonoids and phenolic acids).

Butternut squash is widely grown both in small and large farms in the United States using tilled management practices. Repeated tillage passes over time may lead to reduction in soil health. Soil conserving tillage practices known as reduced- or no-till agriculture could improve soil health. One of the methods for reducing tillage in organic agriculture is rolling and crimping of the cover crop to serve as residue mulch when growing vegetable crops. However, there is a lack of information on the impact of reduced-tillage farming management on nutrient quality of post-harvest stored winter squash fruits.

A research/demonstration project was established in 2016 to evaluate the impact of tillage system (grower standard method) on winter squash yield and post-harvest nutrient quality and compared side by side to reduced tillage system (using either 2-ft wide BCS with roller-crimper or 10-ft wide roller crimper attached to a tractor). Seedlings of butternut squash, 'Waltham,' were transplanted into two-rows per plot with 24-inch spacing between plants. Fruits from 10 plants were harvested in August 2017 per treatment and cured for two weeks. Whole fruit subsamples were taken and stored for 0, 30, and 60 days in a cool and dark room. At the end of each storage date, the fresh pulp was freeze-dried, ground and assessed for minerals at Penn State University AASL and carotenoids at Purdue University.

Results showed that the use of either rolling crimping with either BCS or 10-ft roller crimper in reduced-tillage management enhanced nutrient concentration of α-carotene, lutein, calcium, and phosphorus in winter squash when stored for 60 days compared to grower standard method.

Small-scale and large-scale vegetable growers alike can adopt reduced-tillage management systems to produce winter squash and enhance crop nutrient quality while conserving soil health. In addition, vegetable growers who have limited resources and capital may start by using the 2-ft BCS with a roller-crimper, an affordable low-input technology, to terminate cover crops while producing high-quality winter squash.

Gladis Zinati is a director of the Vegetable Systems Trial at Rodale Institute, Kutztown, PA. Dr. Zinati research focuses on the development of strategies to optimize soil health, weed and insect pest management in organic crop production. These strategies include compost formulations, cover crops, reduced tillage, and natural habitats. She has a set of undergraduate degrees in General Agriculture and Agriculture Engineering and MSc. degree in Horticulture from the American University of Beirut, Beirut, Lebanon. Her Ph.D. is in Soil Fertility from Michigan State University, E. Lansing, MI. She has 24 peer-reviewed publications and 39 proceedings and outreach educational publications, and experienced in giving scientific and educational presentations and hands-on workshops.

TIPS AND TASSELS

Blake Myers
Northeast Vegetable Seed Consultant
Siegers Seed Company
13031 Reflections Drive
Holland, MI 49424

Why buy sweet corn?

Sweet corn "tastes like summer." It is delicious and it is getting better. Today's varieties look better, taste better, and have longer shelf lives than varieties of the past. There is a multitude of ways to fix corn which invites passionate discussions. So, boil it, or grill it. Or wrap it in bacon. Add salt, pepper and butter, or serve it just serve it plain. Pair it with seafood, or a steak, a humble hotdog, or vegan. Few foods are as diverse, and nothing says summer fun like sweet corn.

Selecting a color

Bicolor corn dominates the eastern markets with nearly 80% of sales. Yellow varieties or white varieties each account for about 10% of the market. The yellow should be a soft or bright hue, giving it a fresh appearance. The white should be as bright and pure as possible. For bicolor, the fresh-looking hues are more important than the contrast between the two colors. Bicolor may owe its success to by being the "universal color," or simply because of the sparkle caused by the contrast. But the color itself, does not actually change the flavor. Try to avoid offering too many choices which can cause buyer indecision or buyer's remorse.

A word about the husk

Husks should be as green as possible. To the consumer, pales husks look stressed. While there have been a few varieties that have been commercial successes with reddish husk, neither the breeders nor retailers should conclude that red husks are appealing for the consumer. Under artificial lighting, red husk can appear dry and old or diseased.

Quality is a combination of texture, sweetness and flavor

Overall quality consists of at least three subcategories: texture, sweetness and flavor. When biting an ear of corn, your first sensation is of texture. Is the pericarp (skin) tough and perhaps sticky or is it crisp? Maybe it is tender or perhaps mushy? Do the kernels peel off the cob, or stick between your teeth? Beyond the pericarp, how is the texture of the endosperm?

Next consider the sugars. Are the sugars extremely sweet and sharp like the simple sugars in a supersweet? Some consumers enjoy these simple sugars, and the "sweetest corn they have ever tasted. Other consumers prefer the creaminess and the more muted sweetness of the polysaccharides in synergistic varieties. It's a preference and neither are wrong, but market share and the breeding support the augmented supersweets.

After the sugars calm down on your palate, you begin to sense the flavor. Humans can sense at least 6 flavors (including sweet), and all their various amounts and combinations. Some varieties have a clear or clean flavor. Others are savory, while still others have a metallic or bitter aftertaste. But overall, when the sugars fade, is the flavor pleasing?

Finally, and for the second time after you bite into the ear, you sense texture. What is left in your mouth? Did the pericarp vanish, or do you feel like a cow chewing her cud?

Blake Myers is a vegetable seed consultant for Siegers Seed Company. His territory includes Pennsylvania, New York and New England. He joined Siegers Seed Company in 1994 after working three years for Syngenta (Rogers Brand), and 11 years at Harris Moran. He has his B.S., degree from Purdue University. Blake specializes in sweet corn and evaluates between 400 and 1000 varieties per year. A native of Goshen, Indiana, he lives with his wife, Jennifer, and they have five children. Jennifer and Blake reside in Rochester, NY. The opinions expressed in this paper are his own, and not necessarily the opinions of Siegers Seed Co. (2019)

What can you do about flavor?

Although much of the quality is determined by your variety selection, there are steps that you can take to assure the highest quality on your farm.

First, you need to carefully pick your genotype (Isolation group). You may want to avoid constantly switching between isolation groups, which leads to consumers comparing between your varieties and ultimately being critical of some of your choices. When choosing isolation groups, put your customer preferences in front of your own biases.

Second, chose the best varieties within each genotype. This can be accomplished with experience or asking a trusted grower or seedsman. Also, it is critical to select the correct varieties for your geographic location and maturity slot.

Third, reduce stress. The corn plant is a sugar producing, reproductive factory. Be aware of stresses that inhibit proper root development which is necessary for the uptake of essential elements. Also, watch diseases that either suppress the movement of sugars such as bacteria, or reduce the photosynthetic area, such as rust and blights.

Finally, slow the conversion of simple sugars to starch, by harvesting at the correct time, and if possible, cooling the ears. Getting the core temperature of your packages down to a few degrees above freezing will greatly enhance the shelf life of your product.

How can you predict your harvest date?

Sweet corn varieties may vary in relative days to maturity by as much as 2 weeks. However, varieties are remarkably similar in the time it takes to mature from mid-silk (half silk), until peak harvest quality. The following is a fairly reliable prediction of events. 30 days before harvest the plant bolts (Goes through rapid growth stage shooting up the tassel). 22 days before harvest, the first pollen first begins to shed. 21 days before harvest half the plants begin showing silk on their uppermost ears. This is known as mid-silk and is the easiest to read of all the maturity predictors. The pollen continues to shed until about 18 days before harvest, at which time the anthers become dry. The rest of the events are a bit more subjective to the observer. Around 14 days before harvest the silks have become noticeably dry. 10 days before harvest the ear will begin to show kernel blisters. 7 days before harvesting you should notice color beginning to develop in yellow or bicolor varieties.

The field life, or ability to hold quality is dependent largely on genetics (variety and isolation type), but also on environment conditions and stress.

To help you manage the genetic factors that affect quality, the introduction will be followed with a discussion of the noteworthy varieties from 2019.

EARLY CORN BEST PRACTICES

Early Sweet Corn Using Plastic

Jeanice Ferris Britvich, VP
Ferris Farm Inc
83 Ferris Rd., New Wilmington, PA 16142
Jeanice@ferrisfarm.net

Summary:

- Benefits, equipment and varieties of sweet corn
- Why Plastic?
- Varieties recommend
- PolyPlanter and PolyPlanter Junior

Why Plastic?

- Higher yield and larger ear size
- Earlier crop – up to 2 weeks earlier, plastic color does make a difference.
- Moisture Retention – greenhouse effect keeps moisture in.
- Less Fertilizer – Fertilizer is kept where it is needed.

Varieties for Early Production:

- Vitality
- Sweetness
- Catalyst XR
- Kickoff

PolyPlanter by Ferris Farm

- PolyPlanter can seed most uncoated seeds through plastic (from peppers to lima beans)
- Uses the Monosem vacuum seeder for precision
- Tears a hole does not rip
- Excellent at the singulation of super sweet (odd shaped) and others
- Built to order

PolyPlanter Junior

- Hand push planter for seeding through plastic and bare ground
- More cost efficient then larger planter
- Spacing changes in 10 minutes or less

Tips for a better stand and easier planting:

To get a better stand when planting early sweet corn, prepare ground ahead of time. Plant when you have 3 days of sunny weather in a row to ensure good germination.

Pick a plastic that stretches nicely and will hold up for the length of the season. Last thing you want is it breaking down before ear is forming.

Jeanice Ferris Britvich is the owner and operator of Ferris Farm Inc located in New Wilmington, PA. Ferris Farm Inc is the manufacturer of the "PolyPlanter" and the developer of the "PolyPlanter Junior". She is a graduate of Penn State University with a BS in Business Marketing and Management.
Jeanice took over the business in 2009 and has been running it ever since. She has been involved in the direct development of the Polyplanter Junior. She also own Ferris Farm Produce, a vegetable retail and wholesale market located in New Wilmington.
Jeanice is currently working on more implements for the small to medium farmer to use.
She lives on the farm with her husband, Dr Michael J Britvich (Doctor of Physical Therapy) and her two children, Kayce (7) and Memphis (3).

CURRENT EFFICACY AND MANAGEMENT OF BT SWEET CORN

Dr. Galen P. Dively
University of Maryland, 4112 Plant Sciences Bldg., College Park, MD 20742

Sweet corn producers must rely on timely pest monitoring and effective insecticide sprays to control ear-invading insects. In the mid-Altantic states, corn earworm (CEW) and European corn borer (ECB) are the primary ear invader, followed by sap beetles and fall armyworm (FAW) as secondary pests. The level of infestation varies with year, time of season, and farm location. Corn borer infestations have been lower due to regional suppression resulting from the high adoption of Bt field corn. However, corn earworm typically can cause damage on 10 to 25% of the ears in early plantings, and often greater than 50% ear damage in late plantings if not controlled. Insecticide control programs are costly, involve exposure risks to the applicator and farm workers, and require considerable time and management to implement. Timing the first spray at early silking, applying subsequent sprays on a schedule based on CEW moth pressure, and achieving adequate spray coverage of the ear zone are critical components of effective insecticide control. Corn earworm eggs are laid directly on the silks; once larvae hatch, they quickly move down the silk channel and begin feeding on the ear tip, where they are protected from insecticidal sprays. Thus, it is absolutely necessary to target larvae before they enter the ear by maintaining an insecticide residue on the silk tissue. The pyrethroids have been the popular choice, but they no longer provide enough ear protection due to resistance in CEW populations. Thus is becoming necessary to switch or rotate to more expensive alternative products.

Some of the problems and challenges with conventional insecticide applications can be eliminated with Bt transgenic technology. Bt sweet corn expresses insecticidal toxins from the bacterium, Bacillus thuringiensis (Bt) in all tissues of the plant. This technology has revolutionized the way many corn insect pests are managed; however, corn earworm has developed resistance to several expressed toxins, resulting in reduced field control efficacy, so supplemental insecticide sprays may be required to ensure quality marketable ears. Three Bt corn types are commercially available: Attribute® (expressing Cry1Ab toxin) and Attribute® II varieties (expressing Cry1Ab and Vip3A toxins), both from Syngenta; and Performance Series™ varieties (expressing the Cry1A.105 and Cry2Ab2 toxins) from Seminis Seeds. Toxin expression in these varieties is highly effective against European corn borer, eliminating all whorl and silk sprays in areas where this pest is the primary problem. However, efficacy of the Attribute® and Performance Series™ Bt sweet corn for controlling CEW has been variable since 2008, with increasing concerns over lack of field efficacy. Here, I will present the current control efficacy and management of each Bt sweet corn type.

Attribute® Bt sweet corn has been commercially available since 1996, with varieties BC0805, BC0528, GH0851, BC0822, WH0809, WSS0987, BSS0977, BSS0982, and GSS0966 also expressing tolerance to glufosinate. When first introduced, expression of Cry1Ab toxin provided greater than 95% control of all worms, with minor injury at the ear tip and only small larvae if present at all. This transgenic protection enabled producers to eliminate pre-silk treatments and reduce insecticide applications during silking by more than 80%. However, ear damage, kernel consumption, and numbers of surviving older larvae have progressively increased since 2004 in Attribute® sweet corn. Based on 30 trials evaluated in 2019, percent ears damaged by CEW averaged 66.4% in Attribute® BC0805 compared to 73.2% in the its non-Bt isoline Providence, and 11 of these trials recorded the same or higher ear damage and larval infestations in the Bt plots. Cry1Ab expression still shows some inhibition of kernel consumption and larval development, suggesting that CEW has not completely lost susceptibility to this toxin. This reduction in control efficacy over time is unrelated to corn earworm pressure, because moth activity has actually declined over the past

Dr. Galen P. Dively is a native of Blair County, Pennsylvania where he grew up on a dairy farm. He received his bachelor's degree in biology at Juniata College and doctorate in entomology from Rutgers University. He worked as an Extension Specialist in integrated pest management (IPM) for 34 years, while developing monitoring and decision-making guidelines and educational projects to reduce pesticide use in vegetable and field crops. In the mid-90s, he began studies to address the ecological and resistance risks of transgenic crops, and was the lead or co-investigator on five USDA Biotechnology Risk Assessment Program grants. Since this retirement in 2006, he continues to work part-time at the University and conducts research on pest resistance and field efficacy of Bt corn events, non-target effects of pesticides, evaluation of new insecticides, and the biology and management of invasive pest species.

decade at most trial sites. Currently, many sweet corn producers have stopped growing Attribute® sweet corn or are applying insecticide sprays to compensate for the reduced efficacy.

Performance Series™ varieties include Temptation II, Obsession II, SV9012SD, SV9014SB, and SV9010SA. Besides expressing the dual insecticidal toxins to control lepidopteran larvae, these varieties also express Cry3Bb1 to control rootworms and the Roundup Ready® technology. When Performance Series™ sweet corn was first evaluated in 2010, insect control efficacy was even higher than the level of ear protection by Attribute® hybrids, providing 100% control of fall armyworms and more than 98% control of corn earworms. However, control efficacy against CEW has rapidly declined during the last five years, as evident in Fig. 1 showing unacceptable levels of kernel damage on the ear tip of both Attribute® and Performance Series™ sweet corn. The dual toxin expression still results in more inhibition of CEW kernel feeding and larval development compared to the Cry1Ab sweet corn; and also note that the Attribute® ears in Fig. 1 show extensive feeding injury by FAW on the side kernels, whereas the Obsession II ears are undamaged by this pest. Trials conducted in 2019 showed that an average 57.8% of the Obsession II ears were damaged by CEW (1.23 larvae per ear) compared to 76.6% of the non-Bt isoline ears damaged (1.32 larvae per ear). Currently, because of the reduced control efficacy of Performance Series™ sweet corn, supplemental insecticide sprays are now needed to achieve effective ear protection.

Fig. 1. Levels of ear damage in Attribute® sweet corn (BC0805, left) compared to Performance Series™ sweet corn (Obsession II, right) during 2019. Both hybrids were planted side by side and exposed to high corn earworm and fall armyworm pressure.

Attribute® II Bt sweet corn expresses a new Bt gene combination to broaden the spectrum of activity and reduce resistance development. Introduced commercially in 2013, Attribute® II expresses a vegetative insecticidal toxin, Vip3A, from B. thuringiensis, pyramided together with the Cry1Ab toxin. Varieties Pursuit, Aspire, Remedy, Milky, Patriarch, and Protector also express tolerance to glufosinate and glyphosate herbicides. Compared to Attribute and Performance Series™ sweet corn, these Bt varieties provide excellent field efficacy against CEW and FAW (Fig. 2), including black cutworm and western bean cutworm. In 2019, surviving CEW larvae and kernel damage were recorded in only 19 out of 3677 Remedy ears sampled across all 30 field trial locations. Of these damaged ears, kernel injury was less than 0.5 cm^2 and the majority of larvae were small and feeding only on the ear tip. So far, there is no evidence that CEW is able to survive in Attribute® II ears to older larval stages. These findings are not different from the 2017 and 2018 trial results,; however, several locations in 2019 recorded a few more surviving larger larvae which may indicate evidence of early changes in CEW susceptibility in the Vip3A trait.

Fig. 4. Levels of ear protection during 2019 by Attribute® II sweet corn (Remedy, left) compared to Performance Series™ sweet corn (Obsession II, right). Both hybrids were planted side by side and exposed to high CEW pressure.

Current field performance and management of Bt sweet corn are summarized as follows. First, all Bt sweet varieties provide 100% control of ECB, and there is no evidence of any change in corn borer susceptibility to the Cry or Vip toxins in the mid-Atlantic region. Secondly, the herbicide tolerance traits in these varieties offer a weed control advantage over their non-Bt counterparts. Attribute® sweet corn still provides good control of FAW during the vegetative growth stages but only moderate ear protection; no effective control of western bean cutworm; and generally poor to fair control of CEW. Performance Series™ sweet corn provides very good control of FAW during the vegetative and ear development stages but no effective control of western bean cutworm and only poor to fair control of CEW. Although CEW has developed moderate to high levels of resistance to the expressed toxins, the green silk tissue in the Attribute® and Performance Series™ sweet corn is still consistently toxic to newly hatched larvae, causing intoxication and delayed growth; so those larvae that survive are exposed longer before entering the ear. Due to this wider window of exposure, the first insecticide application in both Bt types can be applied at 100% fresh silking, usually three or four days later than the first application in non-Bt sweet corn under the same insect pressure. Additionally, pyrethroids and other insecticides may actually work better because larvae are weakened by the Bt intoxication. A second spray 3 to 4 days later is usually necessary if high moth activity continues, and sometimes three or four applications may be needed depending on the ear quality required. Attribute® II sweet corn still provides excellent control of all foliage feeding and ear invading worms, thus no insecticidal sprays are required in most cases, except for secondary pests such as sap beetles. Further, the lack of kernel injury in Attribute® II sweet corn significantly reduces the risk of sap beetle infestations, since these insects are mainly attracted to previously damaged ears.

Field-evolved CEW resistance and its associated reduction in control efficacy of Attribute® and Performance Series™ sweet corn confirm findings from studies in the South showing evidence of resistance to Cry toxins in Bt field corn and cotton. Clearly, the high adoption of Bt field corn and cotton, both with moderate dose expression of Cry1Ab toxin being used since 1996, coupled with decreasing refuge compliance, altogether have contributed to the evolution of resistance. Unfortunately, CEW resistance to the Cry toxins will likely increase with the shift to 'refuge in bag' field corn that contains only 5% non-Bt seeds. Furthermore, the Vip3A trait has been licensed to other seed companies, so the acreage of Vip-expressing field corn is expected to increase in the South. Due to northward influxes of potentially resistant moths from the South, this may eventually compromise the efficacy and durability of the Attribute II sweet corn technology.

UTILIZING BIO-NEMATICIDES TO CONTROL PLANT PARASITIC NEMATODES IN HIGH TUNNELS

Timothy Johnson, Ph.D.
Marrone Bio Innovations

Compared to weeds, insects and plant pathogens, plant-parasitic nematodes are often overlooked in crop protection for a variety of reasons. Nematodes are difficult to see, they are difficult and can be expensive to accurately sample, and because they commonly reside in the soil are "out of sight and out of mind". But plant-parasitic nematodes can cause major yield and quality losses in commonly grown fruit, berries and vegetables grown in high tunnel production in the Mid-Atlantic region. To develop a nematode management strategy producers need to understand the biology of the pest nematode species and management options that are available.

Nematodes are ancient soft-bodied roundworms with the ability to shed their cuticle and have multiple juvenile stages before becoming adults. Insects, arachnids and crustaceans are the only other animals with this characteristic. In their over 400 million years of existence, nematodes have evolved to occupy a large number of niches including free-living organisms that feed on fungi and bacteria, human parasites, insect parasites and of course multiple plant-parasitic species. Plant-parasitic nematodes reduce crop yields by reducing nutrient uptake, causing deformation in root structure (galls, root knots, etc.), visibly damaging below ground produce (tuber crops such as potatoes and sweet potatoes) and by transmitting plant pathogens such as Pythium sp. and Verticillium sp. that cause additional yield losses. From a grower perspective, it is important to be familiar with the primary groups of nematodes that are often divided into ecto-parasites, endo-parasites and those that have characteristics of both groups. Nematode behavior is important in determining an effective management strategy. An excellent overview of the behavior of plant parasitic nematodes can be found at the following link: https://www.apsnet.org/edcenter/disandpath/nematode/intro/Pages/IntroNematodes.aspx

So what defines a bio-nematicide? Broadly interpreted, bionematicides are EPA-registered products labeled for the control of plant-parasitic nematodes by EPA's Bio-pesticide and Pollution Prevention Division (BPPD) division. To be eligible for registration as a bio-nematicide or for any bio-pesticide, a product must meet derived from natural materials including animals, plants, bacteria, fungi, viruses and certain minerals. Bio-pesticides fall into three classifications: biochemical, microbial and plant-incorporated protectants (PIPs) and details can be found at the EPA website - https://www.epa.gov/pesticide-registration/biopesticide-registration. People often equate bio-pesticides and organic or NOP-compliant pesticides as synonymous but that is not necessarily so as inert ingredients and production processes are part of NOP compliance. Producers who use bio-pesticides and intend to be NOP-compliant need to be certain that the products they use meet the criteria for the National Organic Program. Checking with your local certifying agency is recommended.

Historically the most widely used nematicides have been broad spectrum fumigants such as methyl bromide, metam sodium, 1,3-dicloropropene, and chloropicrin followed by certain carbamate and organophosphate insecticides such as terbufos and carbofuran that also have nematicidal activity. More recently, fluensulfone has been registered for nematode control in vegetable production. For a variety of reasons these products are not a viable fit for high tunnel production or have significant limitations and there has been a growing interest in developing strategies that include bio-nematicides for nematode management. Today's presentation will discuss how to determine which nematode species are infesting your soil, understanding their life cycle and integrating cultural techniques such as non-host crops with the small number of bio-nematicides that are available to high tunnel producers. There will also

Tim Johnson earned his B.S. and M.S. in Entomology from Iowa State University and Ph.D. in Entomology from Purdue. From 1985 – 2001 he was a Research Scientist and Product Development Manager in various capacities at Ecogen Inc. in Langhorne, PA working on the development of novel bioinsecticides and the identification of novel strains of Bacillus thuringiensis for inclusion in GMO crops such as corn rootworm resistance in corn. From 2008 until present Dr. Johnson has directed global field evaluation activities for Marrone Bio Innovations in Davis, CA with a focus on the development of biologically sourced pesticides for the control of weeds, insects, diseases and nematodes infesting vegetables, fruits and other commodities.

be a discussion at where scientists are looking for new active ingredients for new bio-nematicides.

EPA registered bio-nematicides (may not be inclusive of all registered products)

Product Name	Manufacturer by or for	Active Ingredient	Additional information
DiTera® DF	Valent BioSciences	Myrothecium verrucaria strain AARC-0255*	NOP/OMRI – fruit and veg uses
Majestene®	Marrone Bio Innovations	Burkholderia sp. strain A396*	NOP/OMRI – fruit and veg uses
MeloCon®	Certis USA	Paecilomyces lilacinus strain 251	NOP/OMRI – fruit and veg uses
Monterey Nematode Control	Lawn and Garden Products Inc.	Saponins of Quillaja saponaria	NOP/OMRI Home gardens and lawns
Aveo EZ®	Valent	Bacillus amyloliquifaciens strain PTA-4838	Seed treatment only (corn, soy)
VOTiVO®	Bayer	Bacillus firmus I-1582	Seed treatment only (corn, soy, cotton, sugar beets)
Clariva® pn	Syngenta	Pasteuria nishizawae – Pn1	Seed treatment only (soy, sugar beets)
Dominus®	Isagro USA	Allyl isothiocynate	Biopesticide but not NOP compliant, broad spectrum
MBI-601	Marrone Bio Innovations	Muscador albus strain SA-13	Experimental bio-fumigant
Biofumigation	Publically available seed	Mustard cover crop	Cover crop

*Contains non-viable microbes

ANAEROBIC SOIL DISINFESTATION APPLICATION TO PENNSYLVANIA HIGH TUNNEL PRODUCTION SYSTEMS

Francesco Di Gioia
Assistant Professor of Vegetable Crop Science, Department of Plant Science, Pennsylvania State University

Anaerobic Soil Disinfestation (ASD) is a pre-plant soil disinfestation treatment applied to horticultural crop systems (vegetable, flowers, fruit crops) as an alternative to chemical soil fumigation or soil steaming for the simultaneous management of soilborne pathogens, plant-parasitic nematodes, and weeds. As an organic method, ASD may be applied in both conventional and certified organic growing systems. First developed in Japan and The Netherlands, ASD is generating great interest in China, Europe, and in the US, where it is applied at commercial scale mainly in California and Florida, while it is currently being tested in other states (Tennessee, Maryland, North Carolina, Ohio, Virginia, Washington) including Pennsylvania. In the Mid-Atlantic region the interest for ASD applications is mainly associated to the adoption of high-tunnels for the production of high-value vegetable and small fruit crops that offer limited opportunities for crop rotations, thereby leading to an increased incidence of soilborne pathogens and root-knot nematodes. The ASD treatment is applied amending the soil with an easily decomposable source of carbon (basically sugar) used to feed the soil microbial population and determine a rapid microbial growth and the consequent consumption of the oxygen in the soil, leading to the temporary development of anaerobic conditions. To enhance the development of anaerobic conditions the soil is mulched with plastic film (using preferably total impermeable film) which contributes to limit gas exchanges between soil and atmosphere and is watered via drip irrigation to temporary fill with water the soil pore space in the root zone. As the soil environment turns from aerobic (presence of oxygen) to anaerobic (scarce presence of oxygen), the source of carbon incorporated in the soil is decomposed by anaerobe microorganisms through a fermentation process (similar to the fermentation we have when producing wine, beer, or other fermented products) that leads to the production of carbon dioxide (CO2), methane, volatile organic compounds, and organic acids such as acetic, lactic, propionic, valeric acid which are toxic and/or suppressive of several soilborne pathogens, nematodes, and weeds. In the case of vegetable crops, the treatment is usually applied 3-4 weeks before planting, and the mulching film is punched one-two days before planting the crop to make sure that the soil goes back to aerobic conditions and any metabolite and gas trapped under the film and potentially toxic for the plants dissipate. Being a biological microbial-based method, ASD treatment efficacy is significantly influenced by the soil temperature. Higher soil temperatures generally promote microbial growth and activity determining a more rapid achievement and persistence of anaerobic conditions which are critical for the treatment efficacy. Low temperatures (< 59 F) instead may limit microbial growth and activity, thereby preventing the development of anaerobic conditions even in presence of a source of decomposable carbon. To this regard, the application of ASD in the Mid-Atlantic region requires the attentive selection of the application timing considering that optimal temperatures may occur only between late spring and late summer, which often overlaps with the crop growing season. Under certain circumstances, the use of clear mulching film, may be a simple solution allowing to achieve higher soil temperatures and a higher efficacy of the ASD treatment. Nevertheless, the clear film should be substituted with opaque film or covered with a landscape fabric before planting a new crop, with consequent additional costs. A key component of the ASD treatment is the source of carbon used to activate the microbes and initiate the treatment, and the quality of the carbon source and the amount of carbon applied are both important factors determining the efficacy of the treatment. The main sources of carbon used for ASD application are wheat and rice bran, feed grade sugarcane molasses, and ethanol, nevertheless, crop residues or green cover crop biomass, and organic waste products (grape pomace, spent grain,) of the agri-food industry may be a suitable source of carbon. Besides having a high content of easily labile sugars, the ideal source of carbon should be easy to apply and should

Francesco Di Gioia is Assistant Professor of Vegetable Crop Science in the Department of Plant Science at The Pennsylvania State University. With a 50% research and 50% extension appointment, his integrated research and extension program focuses on developing sustainable vegetable production systems and enhancing vegetable quality. He received his B.S. and M.S. in Agricultural Science and Technology and his Ph.D. in Mediterranean Agronomy working on nutrient management of vegetable crops from the University of Bari in Italy. Before starting his position at Penn State in June 2018, he worked on vegetable crops as a post-doc at the University of Florida from 2015 to 2018 and at the University of Bari from 2012 to 2015.

be available at local level at low cost. Moreover, the ideal source of carbon should have an adequate level of nitrogen and a relatively low concentration of other nutrients in order to provide an optimal nutrition for the soil microbes while avoiding the application of an excess of nutrients.

Over the last year, through a USDA-funded project, a first study has been conducted at Penn State aimed at optimizing the application of ASD under Pennsylvania pedoclimatic conditions and identifying potential sources of carbon. Primary focus of the research has been the evaluation of cover crops as a potential source of carbon. Twelve different cover crops were tested in a preliminary pot experiment for their ability to produce fresh biomass, their concentration of total carbon and nitrogen, and the fraction of easily labile carbon. Of the twelve species, the four most promising species were tested at field scale over the late spring – summer of 2019. In both studies, buckwheat resulted the best cover crop as it produced high levels of fresh biomass in relatively short time and contained high levels of oxidizable carbon. In a follow-up study, buckwheat applied by itself or in combination with blackstrap molasses, assured the development of good levels of anaerobicity compared to standard molasses-based ASD in soil amended with pelletized chicken manure compost mulched with either black or clear totally impermeable film (TIF) provided by Serroplast (Italy). Further investigations are needed to optimize the technique and test the efficacy of other cover crop species and cover crop mixes as well as alternative organic by-products as a source of carbon for ASD applications. Moreover, on-farm test should be performed in order to improve the application method and evaluate the viability of the technique at farm scale.

[1]

INTEGRATED HIGH TUNNEL SYSTEMS FOR IMPROVING ORGANIC VEGETABLE PRODUCTION

Xin Zhao, Craig J. Frey, Jeffrey K. Brecht, and Shufang Tian
Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Use of high tunnels for fresh market fruit and vegetable production has been growing in the southeastern U.S. During 2010-2016, more than 700 high tunnels were constructed with NRCS EQIP assistance in Georgia and Florida. A statewide survey in Florida showed an increase of high tunnel adoption from near zero acreage to approximately 186 acres from 2001 to 2013. A large-scale high tunnel farm focused on salad green production was established in 2016 in north Florida, totaling 125 acres under 800 tunnels for conventional production with an addition of 70 tunnels for organic production in 2018. The increased application of high tunnels as a crop protection and season extension tool for high-value vegetable production in subtropical Florida with sandy soils (>95% sand in soil texture), especially in organic cropping systems, calls for more research-based information to develop integrated approaches toward enhancing crop health, productivity, and quality. We have conducted organic research trials in Citra, FL to compare the high tunnel and open field systems for organic tomato production and to examine the use of compost in high tunnel production of organic spinach. Our current high tunnel organic vegetable system project places an emphasis on assessing integrated nutrient management practices involving cover crops, organic amendments, and organic fertilizers.

Early Blight and Root-knot Nematodes in High Tunnel Versus Open Field Production of Organic Tomato

Early blight, a fungal disease caused Alternaria solani, was identified as the major foliar disease in certified organic tomato production during the Spring 2016 and 2017 trials, while the disease was much more severe in the 2016 season. 'Tribute' and 'Garden Gem' tomato transplants were planted in both high tunnel and open field plots (3 high tunnels and 3 open field plots arranged in a randomized complete block design) on March 9 in both seasons. In 2016, tomato plants in the open field completely declined by June 13 with the final harvest conducted the next day, whereas high tunnel plants exhibited a much lower infection by early blight with a total reduction of 59% in the area under the disease progress curve for disease assessment over time during the season. The improved plant health under high tunnels extended the tomato harvest to July 6, 3 weeks longer than for the open field system. However, our assessment of tomato plant root galling index and soil root-knot nematode population density showed a greater potential for the high tunnel environment to promote root-knot nematode (Meloidogyne javanica) infestation. In 2016, end-of-season root-knot nematode population density in the high tunnel soil was higher than in the open field soil by approximately 250%. Soil temperature modification inside the high tunnel during the production season may be a key contributor to increased M. javanica populations. The root-knot nematode galling ratings were affected by both high tunnel and use of grafted plants. Grafting with the 'Multifort' rootstock effectively lowered tomato plant root galling in both high tunnel and open field plots, with a much more dramatic reduction in high tunnels. Given that root-knot nematode infestation is often a prevalent issue threatening tomato production in Florida's sandy soils, our findings suggest a critical need for monitoring nematode population levels in high tunnel crops. Moreover, integrated practices must be developed for preventative management, such as using resistant cultivars including the use of resistant rootstocks, and soil management practices, e.g., crop rotation, cover cropping, and organic amendments. Considering the high cost associated with grafted transplants, our economic analysis also pointed out that grafted

Xin Zhao is an Associate Professor in the Horticultural Sciences Department at the University of Florida. Her research program is focused on developing integrated vegetable production systems toward improving environmental stewardship, crop productivity, food quality, and farm profitability, and current projects involve application of grafting technology in tomato and watermelon production, organic strawberry production and nutrient management, anaerobic soil disinfestation, organic vegetable cropping systems in high tunnels, and vegetable nutritional and sensory quality attributes as affected by cultural practices. She did her B.S. and M.S. studies in Horticulture at Shenyang Agricultural University in China and received her Ph.D. degree in Horticulture from Kansas State University.

tomato production may be more profitable in high tunnel vs. open field systems under organic production.

Compost Application Method Affected Organic Spinach Establishment

High humidity along with warm, drastically fluctuating temperatures often lead to poor crop growth and quality as well as high disease incidence in organic spinach production in subtropical Florida. Considering the wide use of compost in organic vegetable production, we examined different compost application methods on high tunnel organic spinach establishment and growth. Two methods of preplant application of compost (50% food waste and 50% yard waste compost) were tested, including a tilled control and a furrowed treatment, both at the compost application rate of 20 tons/acre. In the tilled control, the soil was tilled to a 6-inch depth to incorporate the compost applied on the soil surface. The furrowed treatment consisted of applying compost in 2-inch deep furrows. 'Reflect' and 'Corvair' spinach cultivars were direct seeded 0.6 inch deep into amended seedbeds using an EarthWay seeder. Compared with the tilled control, the furrowed treatment increased seed germination percentage and crop stand, with a decreased incidence of damping off. The tilled application of compost showed little influence on soil physical, chemical, and biological properties, while the compost greatly enhanced soil quality indicators in the furrowed treatment. Different types of compost products (e.g., plant based vs. animal waste based) will need to be evaluated to further quantify the impact of the furrowed treatment on high tunnel organic spinach yield performance, taking into consideration the associated economic factors.

Integrated Nutrient Management for High Tunnel Organic Vegetable Production

This ongoing high tunnel project is focused on a systems approach to assess the impacts of cover crops, compost, and organic fertilizer on organic vegetable crop performance. 'Iron & Clay' cowpea was seeded in mid-August 2018 in replicated high tunnel plots and the cover crop biomass was flail mowed and incorporated into the soil in early October. Pac choi was then transplanted and harvested in mid-November, followed by direct-seeded spinach that was harvested twice; the first cut occurring in December 2018 and the second cut in January 2019. Grafted and non-grafted tomato plants were transplanted in late January following the spinach crop. Tomato harvest lasted from early April to mid-June. Results from this first-year cropping cycle showed that cowpea cover crop did not affect pac choi yield and N accumulation compared to the fallow control. Yard waste-based compost increased pac choi yield and tended to increase N accumulation in pac choi compared to the no compost control. Overall, weekly application of a liquid fish fertilizer through the drip fertigation system resulted in higher yield and N accumulation of pac choi than preplant application of a solid fertilizer with nitrogen derived primarily from feather meal and blood meal. In the spinach crop, yard waste-based compost and cover crop treatments showed a positive impact on total yield improvement. In the tomato trial, liquid fertilization led to higher fruit yield than the side-dressing treatment with the solid fertilizer, and grafted plants resulted in an overall improvement of total yield. The yard waste-based compost also trended to increase tomato yield in contrast to the no compost control. In general, tomato yield and quality started to decline in late May owing to high temperatures and increasing pest damages. Earlier planting of the tomato crop in the rotational scheme would likely help extend the duration of crop health and quality and increase the harvest window. Given the microclimate impact on organic nitrogen mineralization, the comprehensive role of cover crop, compost, and organic fertilizer application needs to be further evaluated in developing organic nutrient management programs in high tunnel vegetable systems. Both short- and long-term influence of cover crop and compost on soil quality and nutrient dynamics under high tunnel conditions deserves more in-depth examination.

WINTER ONION PRODUCTION IN HIGH TUNNELS

Lewis W. Jett[1]
West Virginia University, G215 Agriculture Sciences Bldg., Morgantown, WV 26506-6108

Introduction:

Alliums include onions, leeks, chives, shallots and garlic. Within each of these vegetable types, there are many phenological types. For example, onions include the green bunching onions (called scallions), and bulb onions which could be short-day, intermediate or long-day types. In addition, multiplier or potato onions, which are a heritage type of onion are within this group. High tunnels are typically used for warm season crop production in West Virginia through October. This narrows the planting window for winter cash crops. Onions would be well suited for this slot. Onions are cold tolerant crops and can be transplanted becoming established before winter. When spring arrives, the onion resumes growth and would be harvested in April and May. The objective of this study was to evaluate short-day onions, multiplier onions and scallions as a winter high tunnel crop in West Virginia.

Materials and Methods:

Green bunching onions were seeded in 128-cell trays filled with Promix media in early September 2018 and grown as transplants within an unheated high tunnel. Short-day onions, which will bulb when the daylength reach 12 h were purchased as bare-root transplants. Multiplier onions, which are called perennial or potato onions, produce a cluster of onions, were purchased as sets.

Onions were planted in a 30 ft x 72 ft, single poly high tunnel at the WVU Horticulture Farm in Morgantown. The bunching onions were transplanted in early November 2018 and the short-day and multiplier onions planted on November 25, 2018. All onions were planted on black plastic mulch with drip irrigation. Preplant fertilizer was applied based on recommendations from the Mid-Atlantic Vegetable Production Guide. Bunching onions were planted as a 5-row bed with each plant approximately 2 inches apart within row and the rows 6 inches apart. Short-day onions were planted as a 3-row bed with each plant spaced 4 inches apart within row and 8 inches between rows on the bed. The multiplier onions ('Yellow Potato') were spaced 6 inches apart as a double row per bed. To maintain white stems on the bunching onions, they were planted 1.5 inches deeper than the root ball. No supplemental row cover was used on the plants unless the minimum temperature was less than 15°F. Onions were harvested in early May and weighed. Quality was assessed for fresh market

Results:

Table 1. Marketable yield of winter high tunnel onions.

Allium type	Cultivar/Variety	Fresh wt./onion (grams)	Marketable (%)	Quality[z]
Bunching	Evergreen Hardy	27.2	98	4.3
	Guardsman	44.3	100	4.9
	Nabechan	37.1	89	4.6
	Parade	46.8	87	4.9
Short-Day		57.6	100	5.0
Potato (Multiplier)	Yellow Potato	70.4	100	4.9

[z]Quality rating 1-5; 1=poor quality; 5=excellent quality

Dr. Jett is WVU State Extension Horticulture Specialist with an emphasis in commercial, edible horticulture crops. He is a native of West Virginia and has received degrees in agriculture andhorticulture from West Virginia University and Virginia Tech. His research and outreach program focuses on methods to lengthen the traditional growing season and expanding locally grown production of fruits, vegetables, herbs and nut crops as well as evaluating new and diverse types of specialty crops. Other areas of research include stand establishment, seed production, heirloom vegetable production, no-till crop production and organic horticulture.

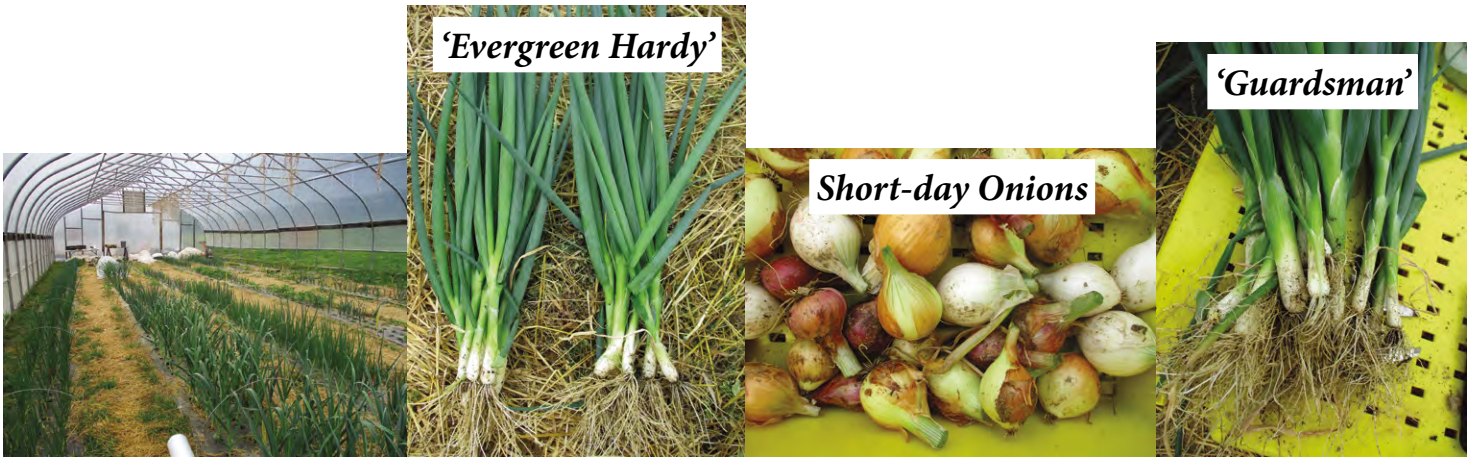


Figure 1. Marketable yield of onions harvested within a high tunnel.

'Guardsman' and 'Parade' had relatively high marketable yield and average fresh weight (Table 1). 'Guardsman' was more uniform and had a higher marketable percentage. Short-day onions had excellent quality and yield. The average size was 1.5 inches in diameter with excellent color and uniformity (Figure 1). The potato onion produces an onion the size of a large shallot. Each plant produced 5-7 onions which were all marketable with excellent quality.

Discussion:

Onions can be a potentially profitable high tunnel winter crop. Onions are very cold tolerant. The winter of 2019 was very cloudy, and this significantly slowed growth of the onions. Growth did not occur until March. Scallions were not marketable until late April to early May while the bulb onions were not mature until mid-May. In previous trials, short-day onions have reached maturity in April. The challenge is that a grower may want to establish a warm season crop in early April before the onions are market size. If that is the case, the warm season crop could be relay interplanted into the onion bed. Onions are a very good companion crop for many warm season vegetables including tomatoes, peppers and cucumbers.

FRUIT CLUSTER PRUNING OF TOMATO IN AN ORGANIC HIGH-TUNNEL SYSTEM

Brian A. Mitchell

Presentation Summary

When was the last time you tasted a fresh and flavorful tomato? Over the years, tomatoes have been bred for many traits, like increased disease resistance and tougher skins for better transport, but flavor was not one of them. So, what can we do to remedy the problem of modern tasteless tomatoes? Local food is part of the solution and is important for many reasons – less transportation is involved and supporting your local farmers creates a more resilient regional food system. Also, patronizing your local farmers market stimulates the local economy and recirculates money back into the community.

There is an increasing demand for both heirloom and organically grown tomatoes, with organic produce carrying a 15-20% premium over comparable conventional produce. Growing for direct markets such as local restaurants, farmers markets, and community-supported agriculture (CSA) is a challenging endeavor, but tools exist to help farmers mitigate risk while growing amazing produce. The use of a high tunnel is one of the most successful tactics to help vegetable growers produce high-quality, high-yielding, and valuable crops.

High tunnels, also known as hoop houses, are used to extend the growing season, lower insect and disease pressure, and trellis crops. They also protect plants from environmental damage (e.g., hail) and have been shown to increase marketable yields. High tunnels are well suited to organic farming and high-value crops like tomatoes, one of the most popular and profitable crops you can grow for the local fresh market. Commercial greenhouses use intensive practices and complex infrastructure, including environmental controls not found in high tunnels, to maximize yield and profit. This includes tight plant spacing, trellising, pruning, lowering and leaning, and other techniques.

The Specialty Crops Program at Colorado State University wanted to explore how fruit load management affected the yield and quality of three different cultivars of tomato in an organic high-tunnel system. Fruit cluster pruning is used to limit the fruit number per cluster and reduces competition to increase individual fruit weight. Fruit thinning is a demonstrated technique in tree fruit production – think apples and peaches – but similar studies looking at this practice in tomato production were limited and produced mixed results. So, we wondered… how would fruit load management affect organic tomatoes intensively grown in a high tunnel in Colorado?

In 2016 and 2017, we grew hundreds of tomato plants on certified organic land at CSU's Agricultural Research, Development, and Education Center in Fort Collins, Colorado (Fig. 1). The Front Range of the Rocky Mountains is a challenging place to grow crops – there is a semi-arid climate, a six-month growing season, and limited water resources. In a 1000 sq. ft high tunnel at our research farm, tomatoes were pruned to have three or six fruits per cluster while the clusters of control plants were left unpruned (Fig. 2). Unpruned clusters developed up to ten fruits! Fruit cluster pruning is straightforward: once you have the desired number of marble-sized tomatoes on the cluster, remove the rest of the cluster with sanitized scissors or garden pruners.

The indeterminate tomato cultivars we studied included 'Cherokee Purple', a widely researched heirloom and consumer favorite, and two hybrids: 'Jet Star' and 'Lola.' 'Jet Star' had performed well in CSU's trials in years past, while 'Lola' has been bred to perform well in greenhouse systems. Indeterminate tomatoes produce fruit throughout the growing season

Brian A. Mitchell is a second-year PhD student of horticulture at Colorado State University. His goal is to provide science-based information to hemp producers and inform the burgeoning hemp industry. His current research looks at organic fertility management of industrial hemp, how hemp functions as a cover crop in irrigated vegetable systems, and how hemp fits into crop rotations in Colorado. Brian has delivered lectures on industrial hemp production in Colorado to students, growers, and industry. He holds an MS degree from CSU, where he researched and published on production techniques to improve the yield and quality of organic high-tunnel tomatoes. In addition to his coursework and research, he serves as the departmental representative on the Graduate Student Council and as the secretary of the Committee on Teaching & Learning. He was a Produce Safety Fellow and a Vice President of Research Fellow in 2018-19. He also works as a lab instructor, teaching assistant, and volunteer within his college.

and benefit from the high tunnel environment and trellising. Intensive, greenhouse-style management was used in the high tunnel: tomatoes were planted densely, trained to maintain a single leader, trellised with twine and cultivated in neat rows, and all foliage was removed below the ripening clusters of each plant.

We were interested in the effects of managing the fruit load per cluster and measured total yield, marketable and unmarketable yields, individual fresh fruit weight, and soluble solids content (SSC) of the different tomatoes under the different treatments. The SSC is roughly the sugar content of the fruit; the ratio of sugars to acidity creates most of a tomato's flavor profile. We harvested over 4,683 tomatoes during the two growing seasons of our study! Over a metric ton of tomatoes later, we found you can grow larger, more sellable fruit without reducing your overall yield or quality. More specifically, individual fresh fruit weight increased for both 'Jet Star' and 'Lola' in the three-fruit treatment, while the heirloom, 'Cherokee Purple,' did not respond to the cluster pruning treatments (Fig. 3).

It turns out that selecting the right type of tomato for organic high tunnel tomato production had the greatest influence on marketability, yield, and quality. There was no decrease in total yield, across all cultivars, between treatments and the unpruned control. This means you can grower larger fruits without negatively impacting your total yield. 'Jet Star' had higher average yields than the other selections, when averaged over two years and other factors. SSC and marketability were more influenced by cultivar than cluster pruning treatments. 'Lola' had a significantly greater SSC than the other two cultivars. 'Jet Star' had the greatest marketable yields of all three tomatoes tested, while 'Cherokee Purple' produced the largest quantity of unmarketable fruits.

In summary, fruit cluster pruning to three fruits per cluster produced larger organic tomatoes without reducing yield or quality for two of three cultivars in the study. The overall "winner" of the study was 'Jet Star,' a compact but high-yielding hybrid tomato that performed very well during both growing seasons. Fruit load management is not uncommon in specialty crops and holds potential in organic high-tunnel tomato production. Fruit cluster pruning is easy, inexpensive, and can increase the size of fresh-market tomatoes without a sacrifice in yield or flavor. After two seasons of research, it held true that cultivar selection remains one of the greatest factors in determining the yield, quality, and marketability of a crop.

Fig. 1. Fruit cluster pruning of organic, indeterminate tomatoes in a CSU high tunnel. Research showed that larger fruits can be produced with certain tomato cultivars by reducing fruit load to three fruits per cluster. This is possible without a negative impact on total yield and quality.

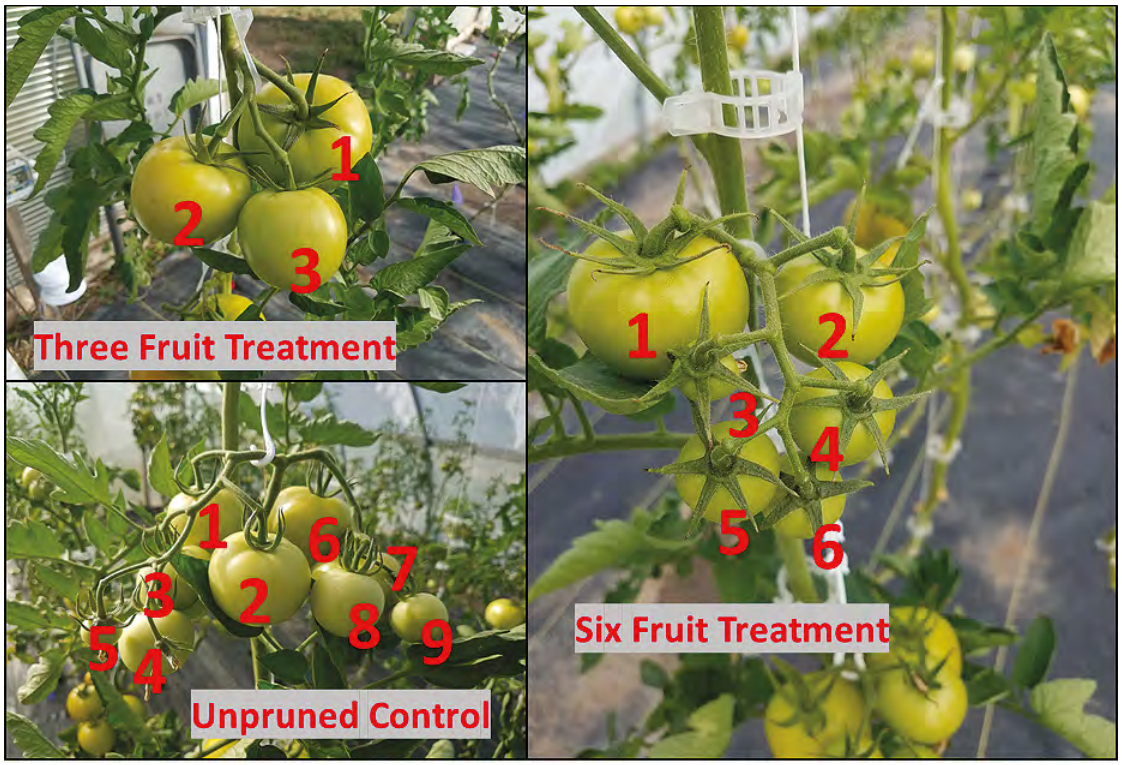


Fig. 2. . A visual representation of the cluster pruning treatments ('Lola') in the study. Clockwise from top left: 3-fruit treatment, 6-fruit treatment, and an unpruned cluster (control), which could set up to 10 fruits depending on the cultivar and growing season.

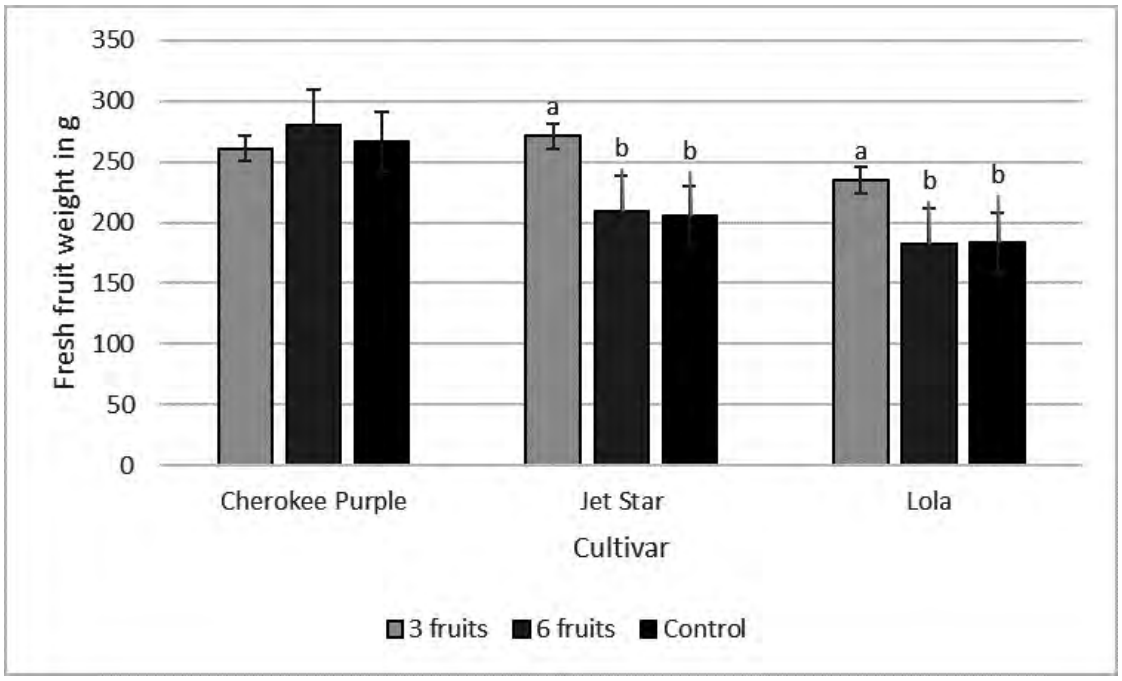


Fig. 3. The treatment effect of cluster pruning on individual fresh fruit weight of organic high tunnel tomatoes. 'Jet Star' and 'Lola' produced larger fruits under the 3-fruit treatment. Data are shown as mean +/- standard error. Different letters represent significant differences at alpha = 0.05 with results averaged over block and year.

INITIATING A BIOCONTROL PROGRAM IN HIGH TUNNEL TOMATOES

Carol Glenister
Entomologist
IPM Laboratories, Inc.
PO Box 300, Locke, NY 13092, Phone 315 497-2063
carolg@ipmlabs.com

Greenhouse tomatoes are where greenhouse biological control all started, at first with whitefly control with Encarsia in the 1930's in Canada and England. Later, in the early 1970's spider mite control with predatory mites became important on cucumbers in both England and the Netherlands where the spider mites had become resistant to pesticides. Today, biological control programs for tomatoes control many pests, including fungus gnats, aphids, thrips, whiteflies, and spider mites.

Start Clean, Stay Clean

Biocontrols are most economical when pest populations are low, so start at or before the very first sign of the pest. Speaking of which, keep pest populations low on the planting that the tomatoes are following so that you do not inoculate your new young tomato plants with pests first thing. In recent years, the upsurge in winter greens in high tunnels has produced many, many overwintering aphids which are transferring over to the tomatoes, which becoming overrun with aphids months before normal. If you have winter greens, do not let the aphid populations build up and infest your spring crop!

Similarly, be sure that your seedlings are started in a clean area that is free of whitefly, thrips or spider mites.

In order to keep pests at bay, ask your supplier to help you create a release schedule that will when you plant the crop.

Indicator Plants

One way to detect the very first sign of a pest is to grow some plants that are especially attractive to the pest in question. Snap beans are a handy indicator plant in greenhouse tomatoes for detecting spider mites and thrips. They are extremely attractive to spider mites and thrips and quickly show damage that is easy to see. Simply grow them in the ground or in pots, and especially place some near the entrances where spider mites are likely to be coming in. For early detection, snap bean plants are the best insurance policy that you can buy!

Natural Enemies for Whitefly Control

Encarsia formosa was first used for control of whitefly in greenhouses in the late 1920's and is still the most effective biological control of greenhouse whitefly today. Beware, however, wherever ornamentals are also grown, there is a good chance of becoming infested with sweet potato whitefly, also known as *Bemisia*. Encarsia is not very useful against sweet potato whitefly, for which you need to obtain an *Eretmocerus* sp. In all cases, excellent control can be achieved if the parasites are released weekly after the first sign of the pest. After 4 to 6 weekly releases, the parasites often will maintain control season long unless more whitefly are brought into the greenhouse on another crop. Anyone who waits until several generations of whitefly occur before starting parasite releases will have great difficulty in regaining control, because a few generations will produce a hundred to a thousand-fold more whitefly for the parasites to attack.

Delphastus catalinae is a tiny lady beetle which specializes in whitefly eggs and small scales, but it does not seem to establish in tomatoes well, and is therefore not used much.

Carol Glenister has pioneered in commercial biological control and IPM since 1974.
She is founder and president of IPM Laboratories, Inc., a 38 year old company that produces and distributes beneficial insects, mites and nematodes. Carol has a BS from the College of Environmental Science and Forestry in Syracuse NY and a Masters from Cornell University. She majored in Entomology for each degree

Natural Enemies for Aphid Control

This is yet another pest where identification is very important to control by parasites. There are three parasitic wasps used in tomato greenhouses. Aphidius colemani attacks melon aphid and green peach aphid, but not potato aphid, also a common pest in greenhouse tomatoes. The more pricey Aphelinus abdominalis and Aphidius ervi attack potato aphid. It is important to repeat parasite releases at least once a week or two after the first release in order to create overlapping generations. Green peach aphid is a moderately large green to pink aphid that is often found on top of the upper leaves. Potato aphid is often found on lower leaves on the tomato plant. Potato aphids are large, long-legged green to pink aphids that will quickly drop off the plant when disturbed.

Aphidius colemani can be maintained on banker plants of barley infested with cereal aphids. European glasshouses have used a grass aphid to support aphid parasites in greenhouses for more than 30 years. Since the aphid does not attack broadleaf plants, it does not pose a threat to broadleaf crops. The aphids are grown on barley or rye. The system does not work for the very large potato aphid parasites, *Aphidius erv*i because the cereal aphids are too small to be hosts for these large aphids. In the case of potato aphid, IPM Laboratories is developing a new banker plant system that offers the larger pea aphids to Aphidius ervi.

One way to get around the aphid identification question is to release the predator *Aphidoletes aphidimyza* which kills many species of aphids. This is a gnat-like fly which lays eggs in aphid colonies that hatch into tiny orange larvae that are voracious aphid predators. Aphidoletes must be released every week for 2 or more weeks in order to create overlapping generations. When daylength is short, they will stop reproducing unless given supplemental light to lengthen the days. The light can be low intensity. Even a street light outside the greenhouse may suffice. A second strategy is to release very small numbers of aphid midges every week and not support reproduction with supplemental lighting. In this strategy, it is important to NOT release the Aphidoletes near known.aphid hot spots which will limit their searching for the aphid hot spots that you have not detected. They are excellent searchers and will be able to find the hot spots that you have detected on their own.

Natural Enemies for Thrips Control

Neoseiulus cucumeris, commonly called Cucumeris, is a predatory mite used for thrips control in tomatoes. It is available in bran that can be shaken from a bottle, or hung from the plants in little packets. With Cucumeris, we strive to create continuous presence of the mites for 4 or more weeks. Since they do not reproduce well on tomato plants, they must be reapplied every 2 weeks for the loose material, or every 3 to 4 weeks for the hanging envelope. It is essential for continuous presence of Cucumeris, because the mite only kills the first larval stage of thrips after the egg. The predator does not attack adult thrips or second larval stage of thrips.

Orius insidiosus is a predatory bug which does not do well in tomatoes, although it is excellent for controlling thrips on peppers

Natural Enemies for Spider Mite Control

The predatory mite, Phytoseiulus persimilis works well for a quick knockdown of smaller two spotted spider mite outbreaks. However, they do not persist well in the tomatoes long term because they do not find tomatoes to be very supportive habitat. The sticky hairs seem to be a particular problem for these predators and seem to prevent them from traveling freely around plants. However, the tiny midge called *Feltiella acarisuga* thrives in tomatoes with spider mites. It does very well in spider mite hot spots, and can fly among hot spots, a better mode of transportation than the mites crawling mode. It is best to release *Feltiella* when spider mites are first seen so that it can establish a breeding population early. Snap bean indicator plants are especially helpful to time the *Feltiella* release, and serve as a comfortable habitat for them to colonize.

Natural Enemies for Fungus Gnat Control

Fungus gnats can be controlled with beneficial nematodes (*Steinernema feltiae)* or predatory soil-dwelling mites (*Stratiolelaps scimitus* which used to be called *Hypoaspis* miles) and/or predatory soil-dwelling beetles, *Dalotia coriaria* which used to be called *Atheta coriaria*. For best results, they should be applied when the crop is first started.

The 2 predators, Stratios and Dalotia are generalists that will reproduce themselves throughout the season, eating soil fauna including thrips pupae in the soil.

Pesticide compatibility

If pests get out of hand, a pesticide may be necessary to knock them down to manageable levels. Insecticides were created to kill insects, and thus will disrupt many of our natural enemies described above. But there are some combinations that people use regularly. The easiest one is beneficial nematodes. Not being insects, they are compatible with many insecticides! But for our other natural enemies, what I am usually most concerned about is the residual effect of the pesticide in question: how many weeks will it kill beneficials for? Many of the old school insecticides can kill the beneficials for many weeks or even months. Insecticides with short residuals include insecticidal soaps, insecticidal oils, microbials like Botanigard and the Bt's, Spinosad, and the azatin and neem products. Compatibility varies with the species, so be sure to ask your beneficials supplier about the combination that you are interested in.

One of the great benefits of biologicals is that they take the resistance pressure off the pests, so that many pests revert back to their genes that are susceptible to pesticides. There are myriad examples where "useless" pesticides have regained their killing power after a year of biocontrols. But this only happens for a single generation, because the resistance is selected for extremely quickly, even in a single generation. With biocontrols, that single treatment may give the only correction that is needed.

Final thoughts

To be successful with biological controls, you must plan to start even before you plant your crop. Prepare in advance to watch for the very first signs of pests and creat a release schedule so that you meet the 1st generation. Weekly scouting is important to be constantly vigilant about upsurges in pest numbers, and to keep aware of any changes in pest species.

CURRENT AND FUTURE RESEARCH ON HIGH TUNNEL VEGETABLE PRODUCTION AT PENN STATE

Francesco Di Gioia
Department of Plant Science, Penn State University

High tunnels are a flexible tool increasingly used in the US and worldwide to provide a certain level of environmental protection to vegetables and other horticultural crops, by creating a more favorable growing environment and allowing an extension of the growing season and an increase of yield and quality of the produce. In Pennsylvania and the Mid-Atlantic region, the use of high tunnels offer an opportunity to expand in terms of volume and seasonal availability the local production of fresh and highly nutritious fruit and vegetables, contributing to assure a higher availability of healthy food and adequate nutrition to the big population of the Northeast US region. From this perspective high tunnels may be considered as a sustainable solution to assure the local production of fresh vegetables and fruits that otherwise must be transported for long distances at high cost in terms of energy, impact on the environment, and produce quality.

Compared to open-field production systems, the adoption of high tunnel technology at commercial scale requires an initial investment, not only for the cost of the structure, but also in terms of time and knowledge required to successfully manage and generate profits using this technology. The high initial investment associated with the construction of high tunnels and their higher management cost is justified only for the cultivation of high-value crops that can generate high revenues. This non-secondary aspect limits the number of crops suitable for high tunnel production systems to only a few options, thereby reducing the opportunity to implement crop rotations with consequent negative effects on soil health and build-up of inoculum for soilborne pests and pathogens that normally would not be a problem. Moreover, the use of high tunnels as a crop protection tool with the exclusion of precipitations and the increase of temperature due to the greenhouse effect of the plastic cover leads to the development of microenvironmental conditions that while may promote plant growth and yield significantly affect the soil microbial activity and associated nutrient dynamics, as well as water flux in the soil-plant-atmosphere continuum. Under such conditions an adequate management of the crop water and nutrient needs is critical for preventing the accumulation of salts, preserving the soil fertility, and assure the long-term sustainability of these intensive production systems.

The developing Penn State vegetable crop research and extension program is currently engaged in investigating technical solutions and innovations that may contribute to enhance the sustainability of vegetable crop high tunnel production systems. Current research and extension integrated projects, some of which funded by the Pennsylvania Vegetable Grower Association, focus on developing advanced solutions for i) the precise site-specific management of irrigation and fertilization of vegetable crops; ii) the sustainable management of emerging soilborne pests and diseases; iii) the management of abiotic stress conditions commonly encountered in high tunnel production systems; moreover, we are trying to iv) assess the effect of different plastic covers on crop yield and quality.

In more detail, working in collaborations with other researchers at Penn State and other research Institutions we are developing and testing the efficacy of sensor-based automated irrigation systems, we are developing and testing the efficacy of alternative methods for monitoring the soil fertility and nutrient availability for vegetable crops grown in high tunnels at site specific level during the growing season, using simple portable ion-selective electrodes. Working in collaboration with researchers from the University of Foggia (Italy) we are testing and calibrating under Pennsylvania environmental conditions the efficacy of "GesCoN" a decision support system for the real-time site specific management of the fertigation of tomato crops using crop growth and nutrient uptake models capable of predicting

Francesco Di Gioia is Assistant Professor of Vegetable Crop Science in the Department of Plant Science at The Pennsylvania State University. With a 50% research and 50% extension appointment, his integrated research and extension program focuses on developing sustainable vegetable production systems and enhancing vegetable quality. He received his B.S. and M.S. in Agricultural Science and Technology and his Ph.D. in Mediterranean Agronomy working on nutrient management of vegetable crops from the University of Bari in Italy. Before starting his position at Penn State in June 2018, he worked on vegetable crops as a post-doc at the University of Florida from 2015 to 2018 and at the University of Bari from 2012 to 2015.

plant growth and nutrient uptake based on real-time weather conditions. Working in collaboration with USDA-ARS researchers we are testing the potential efficacy of grafted vegetables crops in overcoming abiotic stress conditions such as salinity, alkalinity, or specific excess of minerals. Working in collaboration with the same researchers we are testing and optimizing the application of the anaerobic soil disinfestation method for the management of soilborne pest and pathogens under typical Pennsylvania pedoclimatic conditions. Yet, through a small research project and the collaboration with European colleagues we are trying to assess the impact of different type of plastic covers on yield and nutritional quality of vegetable crops.

In the future, we plan to further expand the research and extension activity on these topics and plan to start new line of research to test the potential of alternative vegetable growing systems, novel high-value vegetable crops suitable for high tunnel production systems, and other innovative solutions that may contribute to increase the efficiency and sustainability of current high tunnel production systems.

TIPS FOR MINIMIZING WIND DAMAGE TO HIGH TUNNELS

Kathy Demchak and Matthew Cooper
Penn State Univ., 102 Tyson Bldg., University Park, PA 16802
efz@psu.edu

Wind damage to high tunnels is a common problem and can occur to the plastic covering, the end walls, or the structure frame. Damage can be caused from the force of the wind itself directly, from pressure changes inside and outside of the tunnel, or from repetitive flexing of the plastic or tunnel components that causes fatigue and loosening of parts. Both single-bay and multi-bay tunnels are subject to damage.

This presentation focuses primarily on single-bay tunnels and is based on our experiences with the 20 to 30+ tunnels at Penn State's high tunnel facility since 1999, especially in the last 4 years looking at tunnel design modifications as part of a large research project. This site is quite windy; there are some areas with windbreaks, and some without. Recommendations from researchers and growers with tunnels in very windy locations are incorporated as well.

"Learning Experiences"

There have been many wind events at the research farm since the tunnels were first constructed, but two in particular stand out. These incidents made more obvious which designs were good, and which ones needed improvement.

In the first incident, which happened many years ago, an unexpected storm came through when no one was on-site, and the tunnel sides were rolled all the way up. The tunnel end walls had "wings" that could be folded outwards, while the center section could be lifted up to allow a small tractor to pass through the tunnels. Based on others' experiences and advice, all of us knew that the sides should have been down. In this case though, we saw what happens when they aren't. The wings blew outward on both ends of some of the tunnels, and the end wall center sections flipped out all the way and twisted back onto the top of the tunnels. That must have been where the end walls were when the winds died down, because that's where they stayed.

The second incident happened the night of Feb. 24-25 in 2019. Tunnels had been fully closed and repairs made ahead of time, as a high wind warning was in effect. Data from a weather station belonging to tree fruit personnel showed an average wind speed of 39 mph over 2 different one-hour spans. During these two hours, there were 13 gusts over 50 mph, the highest measuring 58.2 mph. We suspect wind speeds got even higher, because the weather station stopped transmitting data shortly after the 58-mph wind gust, and the anemometer on a different weather station completely blew off.

Our end wall design must have been better this time around, because all end walls came through perfectly intact, even on four tunnels where the plastic came off. Winds came entirely from the west, but only plastic on the eastern side of the tunnels was damaged. It appeared that billowing started after wind came into the tunnels through the western corners, as we don't have corner baffles (aka corner windbreaks) in these tunnels. Because our treated-wood baseboards were now 20 years old, the wood wasn't as solid as it had been, and at least one eye screw - to which the webbing that goes over the tunnel was tied - pulled out on the eastern side. That meant more billowing and some webbing broke. Each of the damaged tunnels also had untreated wooden hipboards to which aluminum cap track was attached. Depending on how solid the hipboard was, various parts of this attachment also gave way. In some cases, the cap part that snaps in over the plastic was lifted out of the base. In other cases, the entire track (base plus cap) was pulled off of the hipboard. In both cases, damage appeared to often start at one corner, as many of the cap and base sections were bent into C-shapes by the time they peeled off. In other cases, the entire hipboard with track still attached just came off. Eventually the plastic tore off of the roll-up pipe, leaving the plastic free to flap in the wind.

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

What was also valuable was seeing where there wasn't damage. None of the tunnels with corner baffles were damaged, and none of the tunnels that used wiggle wire track attached directly to the tunnel frame were damaged, even if they didn't have corner baffles.

Those tunnels that were in line with the windbreaks came through unscathed, but two out of three that were in a gap between the windbreaks were the most severely damaged.

Tips and Techniques

The tips below were developed from our experiences, and also take into account information from tunnel manufacturers, ag engineers, and others.

1) Try to minimize wind exposure. If possible, locate the tunnel in a sheltered area or a location with a windbreak, or consider establishing a windbreak. Rules of thumb based on the Univ. of Nebraska publication "How Windbreaks Work" are that wind will be reduced for a distance to 2 to 5 times the height of the windbreak on the windward side, and up to 30 times the height of the windbreak on the leeward side. That means that you can avoid shading that results from putting the tunnel very close to a tall windbreak but still have its protection. However, the air will go somewhere (it helps to think of wind as water that does not weigh much), so it will go around, through or over the top of the windbreak. Interestingly, this can result in low pressure and turbulence near the leeward side of very dense windbreaks. The tunnel structure itself functions in the same way (see point "3" below). This means that there is an optimum density, height, and length of the windbreak to receive maximum protection.

Conversely, don't put your tunnel where there is a gap in a windbreak. This might seem obvious, but what isn't terribly obvious is that this location may have increased wind compared to a site with no protection at all, due to the wind being funneled through that location.

2) Do what you can to minimize wind entry into the tunnel when winds are excessive. Put the tunnel sides down if high winds are forecast. It's been reported by others that the tunnel can be lifted out of the ground if high winds pass through it. Use corner baffles, make repairs to any holes before expected windy spells, and minimize gaps in the structure as much as you can. For our corner baffles, we use single wiggle wire track to attach a plastic film section to the interior to the end bow and the second bow from each end. The plastic section reaches from the baseboard to the hipboard. Also, keep in mind that much of the damage during wind events occurs from pressure buildup inside of the tunnel when wind gets in. According to A.J. Both at Rutgers who models wind effects, the locations where outward pressure buildup is greatest is at the peak, and in the hipboard area where the tunnel bows curve. So, we shouldn't have been surprised that we had so much damage to the hipboard areas.

3) Make sure that hardware and connections on the "protected" side of the tunnel are as secure as those on the windward side. In high wind events, the greatest damage occurs on the opposite side of the tunnel from which the wind came in part due to low pressure (i.e., suctioning) and turbulence from wind coming over the top, and the pressure in the tunnel mentioned above. Additionally, there are differences in structural support between the two sides. In a situation such as ours where the winds were coming from the west, we realized that when the tunnel sides on the west side are blown inwards, they have tunnel bows behind them to provide support. The plastic on the eastern side is being blown outward from wind that has gotten into the tunnel, and it's also being pulled outwards, and has only the strapping for support. In our case, that's why the damage was mostly on the eastern side.

4) Try to minimize expanses of structure or plastic without support, as this is where damage is likely to occur. Plastic on end walls tends to pull out from behind the batten tape on bigger sections of the end walls, so we're using some extra cross-bracing to make the end walls stronger, and also give the plastic more attachment points.

5) Components made of wood such as hipboards and baseboards can become the "Achilles Heel" of a high tunnel over time, so use metal components where you can. Wood is easy to work with, but metal components such double-wiggle wire track - which can be fastened directly to the structure while also adding structural integrity - are likely to be worth the cost and extra effort in the long run. In our case, we're replacing our wooden hipboards and cap-style track with metal double wiggle-wire track, which as it turns out, is less expensive anyway.

6) Avoid multiple joints where possible, as was in the original end wall design. Make sure that the end walls are securely attached to the end bow in multiple places (ours on a 17' wide tunnel are attached in 7 places to the frame), and also are secured at ground level as well. We used rebar and metal strapping, which we're replacing with small galvanized 2-hole pipe straps.

7) Fix little holes before they turn into big holes. It's harder to make repairs when it's really cold, so check the tunnels and making small repairs in late fall to avoid needing to make bigger repairs during the winter. Pay attention to plastic film "creases" and look for small tears starting there, as plastic film often first tears where it's been creased and folded on the roll.

8) Remember that repairs will always be needed, so have some extra supplies on hand. It's really stressful when you realize that a wind event is forecast, you found a tear in the plastic, and you have no repair tape. Conversely, it's also relief when you find out that you do.

9) Use steel with a gauge and diameter that at least meets NRCS specifications. In most cases where the actual structure was damaged by wind, the structure itself was more lightweight than what NRCS would have specified, and usually was a hoop shape. If using multi-bays, a larger number of bays tends to result in greater stability and reduced damage from wind.

10) When tying webbing to the baseboard, we switched from using eye screws to using eyebolts long enough to go all the way through the baseboards so a washer and nut can put on them on the inside. With a double layer of poly that is inflated, use rope on the sides that is attached to hooks in the hipboard track and to the baseboard to keep the sides from billowing out.

Hopefully by utilizing some or all of the tips above, instances of wind damage can be kept to a minimum.

This work is based upon research supported by the USDA National Institute of Food and Agriculture, Section 7311 of the Food, Conservation and Energy Act of 2008 (AREERA), Specialty Crops Research Initiative under Agreement 2014-51181-22380. This work is supported by the USDA National Institute of Food and Agriculture and Hatch Appropriations under Project #PEN04590 and Accession #1006805. A special thanks goes to to the Pennsylvania Vegetable Growers Association for providing matching funding support.

POTATO INSECT MANAGEMENT UPDATE: INSECTICIDE EVALUATIONS FOR WIREWORM CONTROL

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

For potato growers, wireworms are one of the most difficult insect pests to control. Wireworms are the subterranean larval stage of click beetles. In the Mid-Atlantic U.S., the cornfield wireworm, *Melanotus communis*, is the predominant species attacking potatoes. These insects can remain in the soil for several years attacking potato seed pieces or tubers or seeds and roots of other crops. Wireworms cause damage by feeding on the surface and tunneling into tubers, which reduces tuber marketable quality and creates entry points for plant pathogens that can rot the tuber. In addition to wireworms, white grubs, the larval stage of scarab beetles, also feed on tubers making them unmarketable. Since the early 2000s, my lab has evaluated control tactics for these pests and provided efficacy data for the registrations of various insecticides such as Regent (fipronil), Capture LFR (bifenthrin), and Movento (spirotetramat) for wireworm control in potatoes. Much of this insecticide efficacy information on wireworm management in potatoes can be found in the Virginia Cooperative Extension fact sheet from 2015 at: https://pubs.ext.vt.edu/2812/2812-1026/2812-1026.html

The field performance of most insecticides at protecting potato tubers from wireworm damage can be quite variable. In order to take a closer look into how soil insecticides actually provide their control, i.e., which ones appear to kill the wireworms versus repel them, we conducted a controlled laboratory container experiment.

CONTAINER BIOASSAY

Protocol: Bioassays were conducted in 2018 and 2019 using field collected corn wireworms (Melatonus communis) from the Eastern Shore of Virginia. On 3 April, 2018 and 10 May, 2019, planter boxes (35.8”x 6.6”) were filled with a mix of soil and sand. One potato tuber was buried on one end of the box. A furrow was created in the center of each box and insecticides were applied over an 8” band using a one nozzle boom powered by a CO2 sprayer set at 30psi. On the opposite end from the tuber area, 3 wireworms were introduced into each planter box. On 22 April (19 DAT) and 23 May (13 DAT), the potato was removed and examined for damage, and the portion of soil on each side (potato / wireworm area) was searched for the presence of wireworms to determine if they crossed the insecticide barrier in search of the potato.

The experiment had four replications of each of the following insecticide treatments:

1. Water control
2. Majestene (a new bionematicide from Marrone Bio Innovations that contains heat-killed Burkholderia proteobacteria, which have demonstrated insect efficacy)
3. Capture LFR (bifenthrin, a standard pyrethroid product from FMC)
4. Regent (fipronil)
5. Mocap (ethoprop, an organophosphate that is a top wireworm insecticide)

Tom Kuhar is a Professor and Vegetable IPM Specialist 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 insect pests of potato and vegetable crops. He has trained over 20 graduate students and has published over 120 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.

6. Platinum 75SG (thiamethoxam, a neonicotinoid applied for aboveground pests)
7. Platinum 75SG plus Regent
8. Ethos XB (bifenthrin + a biofungicide from FMC)

RESULTS OF CONTAINER BIOASSAY:

Table 1. Percentage of wireworms* that crossed the insecticide barrier, % survival of those wireworms, and % of potato tubers damaged in 3 ft planter boxes with an insecticide-treated furrow between wireworms and the tuber; Painter, VA 2018-2019

Treatment	Rate per acre	% of wireworms* that crossed the insecticide barrier	% surviving wireworms*	% damaged tubers
Untreated Control		57.5	63.5	84.5
Majestene	2 gallons	34.0	66.0	59.5
Capture LFR	25.5 fl. oz	12.5	32.0	15.5
Regent	3.2 fl. oz	18.0	31.0	47.0
Mocap	1 gallon	6.0	11.0	3.0
Platinum 75SG	2.67 oz	17.5	31.0	34.5
Platinum 75SG + Regent	2.67 oz + 3.2 fl. oz	5.5	35.5	15.5
Ethos XB	16 fl. oz	13.5	32.5	19.0

*Out of a total of 24 wireworms (3 per container x 8 reps)

FIELD TRIAL EXPERIMENTAL DESIGN, MATERIALS AND PROCEDURES:

Location	**Virginia Tech ESAREC, Painter, VA**
Soil Type	Bojac Sandy Loam
Plant Date	4 April 2019
Variety	Superior
Exp.Design	9 treatments arranged in a RCB design with 6 replicates
Plot Size	2 rows x 20 ft with unplanted guard rows

Plot Maintenance	All plots were maintained according to standard commercial practices
Application:	All in-furrow were applied on 14 April at planting at 20 gpa using a single nozzle boom equipped with an 8003VS spray tips powered by a CO2 backpack sprayer at 20 psi. Furrows were cut using a commercial potato planter without the coulters on.
Treatments:	1. Untreated check 2. Regent 2SC (fipronil) 3. Verimark + Regent 2SC (cyazypyr + fipronil) 4. Platinum 75SG + Regent (thiamethoxam + fipronil) 5. Velum Prime (nematicide from Bayer) 6. Torac (tolfenpyrad from Nichino America) 7. Ethos XB (bifenthrin + fungicide from FMC) 8. Capture LFR (bifenthrin)

Pests	Wireworms: *Melatonus communis;* White grubs
Data collection	On 11 Jul, all plots were harvested and tubers were weighed. 100 tubers were selected from each plot and the number of wireworm and white grub damaged tubers was recorded.

All data were analyzed using ANOVA. Means were separated using Fisher's LSD at the 0.05 level of significance.

- Wireworms and white grubs resulted in 14.8% damaged tubers in the untreated check at harvest (Table 1).
- Although wireworms caused only 6.2% damaged tubers in the untreated plots, statistical significance among treatments occurred; all treatments had fewer % wireworm damaged tubers than the untreated check except Velum Prime and Torac (Table 3).
- All treatments also had fewer % grub damaged tubers and fewer total % damaged tubers than the untreated check except Velum Prime (Table 3). In other words, all insecticide treatments significantly reduced insect damage to potato tubers except Velum Prime and Torac.
- Yields were not significantly different among treatments.
- No signs of phytotoxicity were observed.

Table 2. Summary of efficacy of soil-applied Insecticides for the control of soil insects in potatoes; Eastern Shore AREC, Painter, VA 2019

In-furrow at planting treatments	Rate / Acre	% wireworm damaged tubers	% grub damaged tubers	% total damaged tubers
Untreated check		6.2 a	8.7 a	14.8 a
Regent 2SC	3.2 fl oz	2.7 b	2.2 b	4.8 c
Verimark + Regent 2SC	13.5 + 3.2 fl oz	1.7 b	3.3 b	5.0 c
Platinum 75SG + Regent 2SC	2.67 + 3.2 fl oz	2.0 b	2.0 b	4.0 c
Velum Prime	6.5 fl oz	5.8 a	6.2 a	12.0 ab
Torac	21 fl oz	6.5 a	3.2 b	9.7 b
Ethos XB	16 fl oz	1.8 b	0.8 b	2.7 c
Capture LFR	25.5 fl oz	2.3 b	2.5 b	4.8 c
P-value from Anova		0.0010	<0.0001	<0.0001

All data were analyzed using analysis of variance procedures. Means were separated using Fisher's LSD at the 0.05 level of significance. Means followed by the same letter within a column are not significantly different (P>0.05).

SEASON LONG LETTUCE PRODUCTION

Art King
Harvest Valley Farms

Consumption of lettuce has risen dramatically in the US. Per capita consumption has risen from 8 lb. in 2005 to 15 lb. in 2017. So basically, if you are not growing lettuce, you are missing out on sales. Compared to other vegetable crops lettuce is fairly easy to grow. The advantages are; seeds are not expensive, quick starting time (4 weeks), few days to harvest (usually 4 weeks from transplant), flexible harvest window. There are some disadvantages, but these can be overcome; transplant shock susceptible, specific post-harvest handling needs, limited shelf life. We begin our season in late February in the high tunnel. We heat two 30x96 tunnels with a giant wood burner, trying to keep the nighttime temperatures around 45 degrees. Transplants are put into the raised beds and overhead watered. Usually we are able to harvest in 4 to 5 weeks depending on the night time temperatures. We also grow spring mix then as well. Jonny's gourmet lettuce mix has done well for many years. It can be harvested at 5 inches tall, then again in a week to 10 days. Three harvests are possible. This has proven to be our most profitable high tunnel crop. It is especially good in the high tunnel raised beds because there is no weed pressure.

Field transplants are started in early March in the greenhouse, then every two weeks till mid September. Ellie pot plugs are used for lettuce transplants. They are somewhat expensive, but we have found them to be worth the .04 per plug cost. The size of the plug is perfect to achieve the correct height for the transplant in the raised bed plastic in the field. The key to getting a good stand when transplanting is to use lots of water. We saturate the plug trays an hour before transplanting. Then in the field, the waterwheel hole in the plastic is filled with water when the plant is inserted. A double 12" row is planted on the bed, with a small toothed wheel, 1 ¾ x 1 ¾.

We use white plastic except for the first and last plantings. The white plastic reflects the heat. We do not use any irrigation. The worst pests and slugs and cucumber beetles. When it is hot and dry, there is little slug pressure, but the majority of the time a pinch of slug bait is hand applied near the base of each plant about 1 week after transplanting. The crop needs to be monitored for cucumber beetles weekly. We use neem oil based insecticide for cucumber beetles.

Post-Harvest Handling

We always harvest the lettuce in the morning when it is cool. Our plastic bins (with only bottom holes) usually hold 12 heads. Then the lettuce is washed in cold water with a disinfectant. It then goes to the cooler at 40 degrees. If we are taking it to a farmers market or an off-site CSA, the bins get a layer of ice before going into the truck. At our market it gets bagged before going to the vegetable display cooler. Customers frequently tell us that our lettuce keeps for two weeks in their refrigerator. I believe that the post-harvest handling is the key to selling lots of lettuce and demanding a high price.

Art King, of Harvest Valley Farms, farms in partnership with his brother Larry and son David. Harvest Valley Farms is located in Valencia, Pennsylvania, 20 miles north of Pittsburgh. The farm's market base consists of 100% retail including a Farm Market and Bakery Store, three Farmers' Markets, a 540- member CSA, and a Pick-Your-Own Pumpkin Fall Festival. They grow 160+ varieties of vegetables and small fruits on 160 acres.

TWO YEARS OF HEAT-TOLERANT ROMAINE LETTUCE TRIALS, RESULTS AND INSIGHTS

Crystal Stewart-Courtens and Natasha Field

2018 Standout Varieties

- Augustus – sweet through two first plantings, average 12 oz heads but had average disease resistance
- Breen - sweet in first and last plantings, average 3.8 oz heads and had good disease resistance
- Dragoon – sweet in first two plantings and bitter in last, average 5.5 oz heads with average disease resistance
- Fusion – sweet in the second planting and average taste in the first and third plantings, 12.3 oz average heads and good disease resistance
- Holon - sweet in first and last plantings, average 10.7 oz heads but had average disease resistance
- Kalura - sweet through two first plantings, average 12.3 oz heads but had average disease resistance
- Romulus – sweet in all plantings, average 9.8 oz head but had average disease resistance
- Spretnak - sweet in all plantings, average 7.7 oz head, had good disease resistance

2019 Standout Varieties

- Dragoon – sweet tasting, excellent taste and great disease resistance. 14.2 oz head
- Fusion - sweet tasting, excellent taste and great disease resistance. 14.2 oz head
- Salvius – not bitter or sweet but great tasting and great disease resistance. 13.6 oz head
- Coastal Star - not bitter or sweet but great tasting and great disease resistance. 12.9 oz head
- Zeb Romaine – mini romaine with a 5.8 oz head. Sweet with excellent taste. Average disease resistance
- Jericho – not bitter or sweet but good tasting and good disease resistance. 20.4 oz head, second heaviest in the trial!
- Olga – a bitter lettuce, but good tasting, with good disease resistance. 19.2 oz head.

Overview

The 2018 lettuce variety trial was conducted at Pleasant Valley Farm in Argyle, NY. The main goal of the trial was to evaluate romaine varieties to see which would perform well in hot summer conditions. We had three plantings over the summer.

First planting: May 28th, harvested August 1st, had 17 days above 85 degrees, GDD (Base 45) 1612

Second planting: July 15th, harvest September 15th, had 15 days above 85 degrees, GDD (Base 45) 1711

Third planting: August 1st, harvest October 3rd, had 12 days above 85 degrees, GDD (Base 45) 1525

The 2019 lettuce variety trial was conducted at Philia Farm in Johnstown, NY.

First/only planting: May 29th, harvested July 23rd, had 12 days above 85 degrees, GDD (Base 45) 1304

We evaluated the varieties based on the number surviving to harvest, the number harvestable, the number bolted, disease pressure, bitterness, taste and the weight of one average head.

Ratings

Bitterness: on a scale of 1-3 with 1 being bitter and 3 being sweet

Disease: on a scale of 1-5 with 1 being extremely sick and 5 having no disease present

Taste: While personal tastes play a role, three different people tasted the lettuce, and their rankings were averaged to minimize personal taste preference on a scale with 1 being bitter, 2 being neither bitter nor sweet and 3 being sweet.

Crystal Stewart works with diversified organic, small and beginning vegetable farmers throughout eastern New York, helping them to improve both their sustainability and profitability for long-term success. She works closely with the Amish communities in the region, and actively supports to development of marketing opportunities including a local produce auction and consumer cooperatives. She provides on-farm support to address pest and disease issues and cultivation of all vegetable crops with statewide responsibility for garlic.

Weather

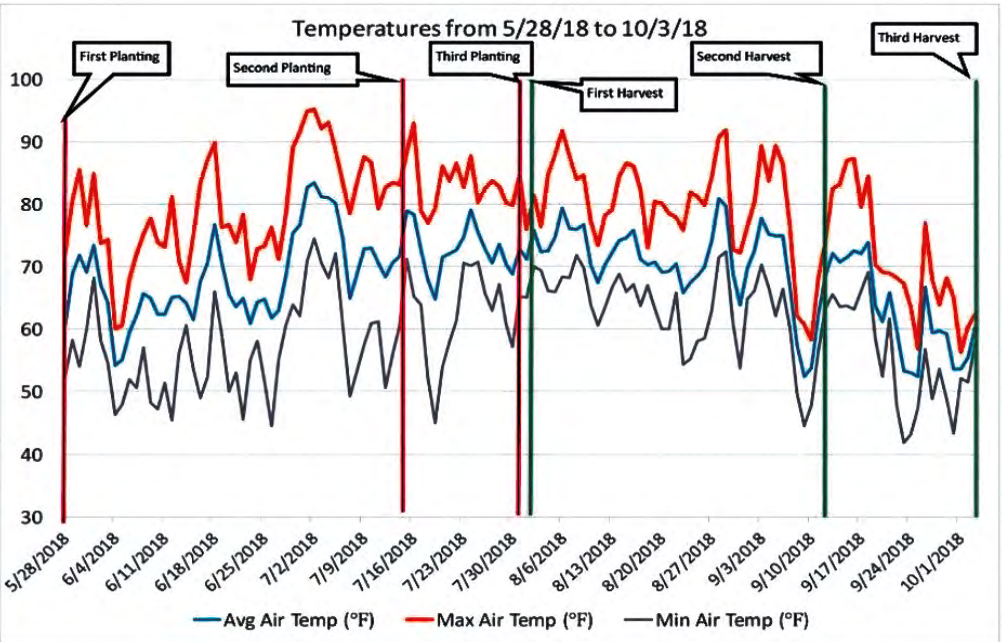
One of the most important factors is the number of plants bolting. Often this leads to bitter leaves and odd head shapes and sizes that are unmarketable. In general, the varieties that bolted did so across more than one planting, with the most plants bolting in the first planting. As you can see in the chart below, the first planting in 2018 had more extreme temperature swings as well as the most days over 85 degrees. The first planting had 71 plants bolt, 15% of plants.

Surprisingly, the second 2018 planting had the least amount of plants bolting. It had more heat units but less temperature swings. It was just consistently hot. Only 14 plants bolted during this time despite inconsistent irrigation and the hot and humid temperatures.

The third 2018 planting did have some extreme temperature swings, although it was getting in to the cooler months. Those plants did experience heat stress in August. 41 plants bolted.

None of the varieties that bolted were in the average to sweet category in bitterness.

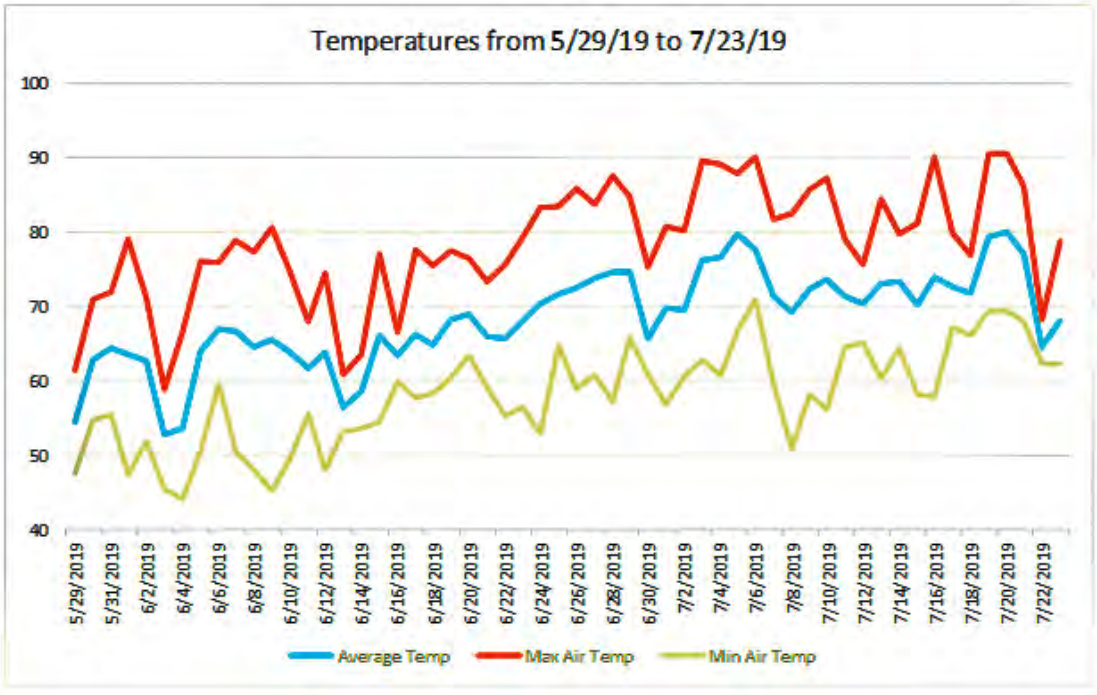
2018 Weather Chart



In this 2019 planting, only a few varieties bolted when we harvested and evaluated at 55 days from planting. However, just 6 days later, most of the varieties had bolted, leaving only a few able to be harvested. Those that were still marketable were: Salvius, Breen, Coastal Star, Cherokee, Nevada, Fusion, Dragoon, Truchas, Plato II, Jericho, and Sparx.

2019 was cooler than 2018 during the growing period, with only 12 days above 85 degrees and a slow increase to those high temperatures as seen on the chart below. In 2018, the plantings that had the most sudden temperature swings from cool to hot had more plants bolting. 85 degrees is when lettuce will stop growing and experience greater heat stress, leading to bolting. Given that most varieties bolted quickly after we evaluated, keeping a close eye on your lettuce during extreme heat and humidity is extremely important to have heads that are still marketable.

2019 Weather Chart



Where to Find the Full Variety Reports

2019 Report - https://enych.cce.cornell.edu/submission.php?id=683&crumb=crops|crops|lettuce_/_leafy_greens|crop*17

2018 Report - https://enych.cce.cornell.edu/submission.php?id=618&crumb=crops|crops|lettuce_/_leafy_greens|crop*17

If you can't get to the above links, go to https://enych.cce.cornell.edu/, and scroll through the crops near the top until you get to lettuce, click the lettuce box and it will take you to the page with all of the lettuce variety trial information. You can also request physical copies of these reports by contacting Crystal at cls263@cornell.edu or at (518) 775-0018.

MULTIPLE WAYS TO GROW SPINACH

Dave King,
Harvest Valley Farms, Gibsonia PA

Introduction:
Spinach is one of our most popular crops in the early spring, spring, fall, and late fall/early winter. Here are the multiple ways that we grow spinach in order to accommodate the fluctuating weather/temperatures in order to be as efficient/economic as possible, as well as, maximizing our spinach harvest in one growing season.

Please keep in mind that ALL of the spinach that we grow is leaf harvested by hand with a knife, at maturity, and washed, weighed, and bagged.

Also keep in mind that we have cold, heavy clay soils.

The only variety that we grow is Green Bert…We have tried many and this is by far the best for how we grow and sell our spinach.

Plug Transplant into Plasticulture:
Sow 2 seeds per cell into a 200-cell tray. Lay 8" high raised beds with 4ft embossed white on black plastic mulch (white side up). When the bed is being formed with a rainflo mulch layer, we are also applying 350lb/acre high nitrogen fertilizer and double 12" drip tape 2" below soil surface. After beds are formed, we are planting 8 transplant plugs per ft. 7" between row and 6" in row spacing (4 rows per raised bed). We do this by using a custom made 55-gallon drum with spikes welded in this pattern, then rolled down the row with either a water wheel transplanter or by hand depending on the field moisture levels. Plants are planted by hand using ridged butter knives, or just pushed in depending on soil moisture.

High Tunnel Transplant Production:
Spread 1" of composted manure and till soil in January or February. Cover tilled area with some type of black plastic or black silage tarp. (This germinates weed seeds and kills them over a month or two of being laid down) We pull the cover off in mid-march and will run lines of 6" drip tape on the bare ground. Usually 6 rows, spaced at 6 inches apart, per "bed". We then turn the water on and plant one plug at every dripper.

Field Direct Sow:
We only direct sow in the late fall due to weed control. Mid-August we will prepare a field just like we would with plasticulture (same machine that makes a raised bed and applies fertilizer) but without laying any plastic. We then cover the entire field with a black plastic or silage tarp (to kill weed seeds). We remove the cover and direct seed 6 rows per bed using a 3 head jang precision seeder (go one way then go the opposite direction on the same bed. One seed every 2-3 inches.

David King, is a partner of Harvest Valley Farms. He is in partnership with his father, Arthur King, and uncle, Larry King. He has a B.S. in Agricultural Sciences with a minor in Horticulture from Penn State University. Harvest Valley Farms is located in Valencia, Pennsylvania (20 miles north of Pittsburgh). The farm's market base consists of 100% retail including a Farm Market and Bakery Store, three Farmers' Markets, a 540 member CSA, and a Pick-Your-Own Pumpkin Fall Festival. They grow 160+ varieties of vegetables and small fruits on 160 acres. Some of Dave's specialties on the farm include high tunnel production, employee management, plasticulture production, drip irrigation, website management, welding, and equipment maintenance. He and his wife, Alicia, live on a 35-acre farm in Allegheny County. They have three little boys, Eli (5), Logan (3), and Brody (1). David also was awarded as one of the top 40 under 40 Farmers in the US in 2018.

COMPREHENSIVE EVALUATION OF LETTUCE FOR FARM-TO-HOSPITAL MARKET

Winter Lettuce Production

Lewis W. Jett
West Virginia University Extension Horticulture Crops Specialist


Figure 1. High tunnels can be used for extended season head lettuce production.

Lettuce (Lactuca sativa L.) is a high-value crop for many retail and wholesale markets. Lettuce is a cool season crop with an optimal temperature for growth of 60-65^{0}F, yet it may be possible to grow a lettuce crop year-round in the Mid-Atlantic region using a combination of suitable varieties and season extension technology (Figure 1).

Lettuce is the second most widely grown crop within high tunnels in the United States behind tomatoes. Bibb and romaine head lettuce are two popular head lettuces. Bibb lettuce or butterhead lettuce has loose, open heads with soft or tender leaves while romaine or cos has long, firm leaves with prominent midribs (Figure 2). Bibb lettuce is an excellent choice for expanded local production because it does not ship well over long distances. Romaine lettuce has a more vertical or upright growth and produces a very dense head of leaves. Both types of head lettuces can be harvested at the baby stage for specialty markets,


Figure 2. Romaine (left) and bibb (right) lettuce for extended season production.

Dr. Jett is WVU State Extension Horticulture Specialist with an emphasis in commercial, edible horticulture crops. He is a native of West Virginia and has received degrees in agriculture and horticulture from West Virginia University and Virginia Tech. His research and outreach program focuses on methods to lengthen the traditional growing season and expanding locally grown production of fruits, vegetables, herbs and nut crops as well as evaluating new and diverse types of specialty crops. Other areas of research include stand establishment, seed production, heirloom vegetable production, no-till crop production and organic horticulture.

Recommended Varieties

Table 1. List of lettuce cultivars recommended for high tunnel production in West Va...

Cultivar	Days to maturity[z]	Description
Bibb types:		
Alkindus	60	Red bibb
Nancy	52	Boston bibb type
Rex	50	Hydroponic type with good heat tolerance
Skyphos	47	Red buttercrunch
Red Cross	48	Red buttercrunch with heat tolerance
Buttercunch	46	Green bibb
Batavian types:		
Nevada	48	Green batavian; heat & cold tolerant
Magenta	48	Reddish green batavian
Cherokee	48	Red batavian
Romaine types:		
Dov	76	Heat tolerant summer romaine for extended season production
Monte Carlo	53	Green romaine
Jericho	58	Green romaine with heat tolerance
Coastal Star	58	Green romaine with heat tolerance
Breen	45	Red mini romaine
Green Forest	56	Green romaine
Salvius	58	Green romaine
Winter Density	54	Dark green romaine
Pomegranate Crunch	54	Miniature red romaine

[z]From direct seeding under optimal conditions.

Table 2. Yield and quality of cold weather lettuce trials 2016-17.

Variety	Type	Wt./head (lbs.)	Diameter (in.)	Quality	Marketable (%)
Green Forest	*Romaine*	1.1	10.5	4.8	72
Truchas	*Romaine*	0.6	9.2	4.6	56
Monte Carlo	*Romaine*	1.2	10.3	5.0	83
Bambi	*Romaine*	0.8	8.2	4.2	89
Dragoon	*Romaine*	0.8	10.4	3.7	61
Muir	*Batavian*	1.1	11.9	4.4	78
Concept	*Batavian*	1.1	11.7	4.6	72
Nevada	*Batavian*	0.9	10.7	4.1	72
Magenta	*Batavian*	1.3	11.3	4.8	89
Cherokee	*Batavian*	0.8	11.3	5.0	89
Ilema	*Lollo rosa*	0.7	11.3	4.6	72
Mirlo	*Bibb*	1.1	11.0	4.5	92
Red Cross	*Bibb*	0.8	12.6	5.0	89
Skyphos	*Bibb*	0.7	10.6	5.0	78
Buttercrunch	*Bibb*	0.9	10.2	3.7	94
Green Star	*Leaf*	1.0	12.3	3.5	84
Green Sweet Crisp	*Salanova*	1.0	12.5	4.4	94
Standard error		*0.03*	*0.2*	*0.1*	*3*

High Tunnel Planting

Lettuce can be established within a high tunnel every season of the year. Under optimal conditions, 50-75 days from seeding will be needed to begin harvest. When planted later in the year, the length of time from seeding to

harvest increases. However, head lettuce for winter production should be planted before mid-November in West Virginia. Sequential planting for uninterrupted supply can be done every 2-3 weeks until mid-late November. Bibb lettuce should be spaced 8-10" apart within the row and 8-12" between rows. Romaine and Batavian lettuce should be spaced 10- 12" between plants and between rows on the bed. Typically a 3-4 row bed is optimal for lettuce production within a high tunnel. Plastic mulch is recommended since the mulch will be effective in regulating soil temperature and reducing soil moisture evaporation. In addition, the mulch helps to reduce soilborne diseases. Black plastic mulch (embossed) is recommended for early spring, fall and winter lettuce production, while white or reflective mulch should be used for summer lettuce production (Figure 4).
Lettuce requires frequent irrigation for optimal yield and quality. Drip irrigation with medium flow drip tape should be used for full season lettuce production. Each bed should have 2-3 drip line laterals. A 6-9 hour irrigation cycle per week should be followed depending on the season of the year. Beginning in mid to late November, irrigation can be curtailed.

Nutrient Management

The optimal pH for lettuce production is 6.5-6.8. Approximately one pound of actual nitrogen (N) per 1000 ft^2 is applied prior to planting lettuce. The remaining 0.5 lbs. of actual N per 1000 ft^2 of bed space can be applied through the drip system over the remaining 4-6 weeks of growth. Phosphorus (P) and potassium applications should be based on the most recent soil test. If phosphorus and potassium levels are optimal, fertilizer such as calcium nitrate (15.5-0-0) is recommended for lettuce production. Six pounds per 1000 ft^2 can be applied prior to planting and the remaining 3.2 lbs. injected in the irrigation water over a 4-6 week period.

High Tunnel Temperature Management

The optimal temperature for production of head lettuce is 65-75°F. Thus, venting should be controlled to reach this temperature range. Most head lettuces will grow if the temperature is >40°F. When air temperatures exceed 85°F for extended periods of time, the lettuces will often bolt (produce a seedstalk), devlop tipburn or become bitter. A 30-50% shade cloth can be used to reduce air temperature within the high tunnel. Summer lettuce should be grown on white plastic mulch and irrigated daily. Row covers should be used to modify temperatures for lettuce growth. A 0.8-1.0 oz. /yd^2 row cover is recommended. When the minimum (night) temperatures are forecast to be lower than 40°F, row covers should be applied to the lettuce crop. The following morning (temperature permitting) the rowcovers can be removed. Avoid growing lettuce for extended periods of time under row cover since this will often produce tip burn symptoms on the leaves.

Pest Management

Common pests of lettuce and other leafy greens include aphids, slugs and grasshoppers. Routine scouting of the rows should be done to detect aphid "hot spots". These areas can be treated before the pest invades the rest of the crop. There are several organic and "soft" pesticides for aphid control. Consult the *Mid-Atlantic Commercial Vegetable Guide* for more information. Slugs can be controlled with iron phosphate baits while larger insects such as grasshoppers or crickets can be controlled with insect exclusion screens.

LEAFY GREENS PEST MANAGEMENT

Gerald Brust
University of Maryland


FIG. 1

There is a complex of **Lepidopteran larvae** that can cause damage to many leafy green species. While there are some differences in biology most of the worm species are similar in damage. Diamondback moth, *Plutella xylostella*, (DBM) and cabbage looper, *Trichoplusia ni*, are the two most destructive worm pests of leafy greens. DBM lays eggs singly on the underside of leaves. The larvae hatch in a day and feed on the underside. The larvae grow as large as 5/8 inch. Larvae are green and hang by a silken thread when disturbed. First damage appears as small incomplete holes called *windowpane* (fig. 1, arrows), caused by very young larvae with later damage being larger holes. The entire plant may become riddled with holes under moderate to heavy populations. The pupae of DBM is green and encased in a netlike cocoon that is attached to the foliage. Pupae reduce quality as a contaminant. The life cycle may be as long as 50 days at low temperatures and as short as 15 to 20 days during high temperatures. Cabbage looper is often the second most destructive pest to cabbage and leafy greens. The cabbage looper is most destructive in early summer and fall. The larvae are large worms (up to 1 ½ inches) that cause large holes in the leaves. Larvae are sluggish and hold on to the plants persistently when trying to remove them. The eggs are laid on the underside of the leaves and larvae hatch and feed on the underside, with the pupae attached also to the underside in a protective cocoon. The beet armyworm, *Spodoptera exigua*, is usually a pest of fall plantings of collard, kale, mustard and turnip. Heavy populations that have increased on other crops move to greens when food sources become scarce. Because it often is resistant to most commonly used insecticides the beet armyworm has become one of our most difficult caterpillars to control. The moth lays masses of eggs that are covered with scales giving the mass a cottony appearance. Larvae are light green to dark olive green and sometimes have stripes of these colors down the back. Above the second pair of legs near the head end is a black spot. The imported cabbageworm, *Pieris rapae*, is rarely an economic pest on cabbage and leafy greens if controls for other worms are being applied. The adult is a common butterfly that lays eggs singly on the leaf surface. The larvae are green with a light yellow stripe down their back and have a velvety appearance.

Several species of aphids are found in leafy crops and as with worm pests their damage is similar to one another. Green peach aphids, *Myzus persicae*, are pale yellow to green with winged forms being slightly darker. Potato aphids, *Macrosiphum euphorbiae*, are either pink or green and are much bigger than green peach aphids. Potato aphids have long legs, antennae and cornicles and stay together to form dense colonies on the undersides of leaves. All aphids feed on phloem sap sucked from leaves and stems through their long piercing-sucking mouth parts. Excess water and sugars are emptied from the body via the cornicles. These deposits (honeydew) on leaves serve as a source of food for sooty mold fungi (fig. 2), as well as ants, sap beetles and flies. Winged or wingless adult females give birth to live nymphs.


FIG. 2

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

Adults produce from 3 to 5 nymphs per day for up to several weeks. The nymphs pass through several instars before molting into adults in 7 to 10 days. Green peach aphids usually spread out on leaves unless densities are very high. Potato aphids usually form dense colonies. Aphids are more of a problem for spring and fall leafy crops. Heavy aphid pressure on seedlings can reduce vigor and stunt plants. Honeydew from aphids produces a sticky jumble inside heads and encourages sooty mold growth. However, aphid contamination of heads is considered the greater problem. Aphids move down older leaves and up into the developing heads of leafy vegetables where they encounter more consistent temperature and humidity and protection from many natural enemies and insecticides.

Flower thrips, *Frankliniella spp*. are narrow, pale yellow to brown to black, and approximately 1/16 in. long. The narrow whitish eggs are inserted into plant tissue. Larvae emerge in 3 days to feed in flowers or on leaf tissue. Adults and larvae feed using their mouth parts to rupture and feed from epidermal cells. Larvae develop for two instars before entering the third instar, that molts into the pupal stage. Thrips can complete a generation in 2-3 weeks. Most of the thrips feeding on leafy vegetables develop elsewhere, frequently on flowering weeds surrounding fields. Adult thrips often move into leafy crops from nearby fields, roadsides or ditch banks by the thousands within hours of when their previous host plants senesce or are destroyed. Large numbers of thrips can damage leaves by excessive feeding. Areas of heavy feeding appear more reflective or silvery in color.

A new pest in our area, the **yellowmargined leaf beetle**, *Microtheca ochroloma*, is a small beetle that infests turnips and mustard, especially at field margins. The beetle is dark gray with a yellow margined wing cover (fig. 3; photo by M. Skvarla, Penn State). The larvae are black and cigar-shaped with three pairs of thick legs. The larvae and adults feed on foliage, leaving them with a laced appearance. The pupae may be found in white, round, and loosely woven cocoons near the crown of plants.


FIG. 3


FIG. 4

Red legged winter mites *Penthaleus dorsalis* thrive in what we would normally consider conditions too cold for an arthropod to cause problems. This mite is cold adjusted and cannot stand hot dry soil conditions and will die as summer heat approaches. Eggs are laid in late spring and they over-summer in the soil. These are stress resistant eggs (i.e., they can withstand drying and heat as well as synthetic chemical applications). In the fall they will begin to hatch, and mites will be active throughout the fall and winter inside a high tunnel with leafy crops. Damage appears as 'silvering' or 'whitening' of the attacked foliage (fig. 4). Mites are most damaging to newly emerging crops, greatly reducing seedling survival and development.

Flea beetles, several species, live through the winter as adults in leaf litter, windbreaks and wooded areas. Adult flea beetles become active in early spring. Depending on the species, females lay single or clusters of eggs in small holes, in roots, soil or leaves of many vegetables. Small white larvae hatch from eggs and feed on the roots of the newly planted seedlings. Larvae then transform into pupae in the ground. There are usually one to two generations per year. All species of flea beetles cause similar damage. Adult flea beetles cause the most damage by feeding on the leaves and stems. They create shallow pits and small rounded, irregular holes (usually less than 1/8th inch) in the leaves. This type of damage is unique to flea beetles. Plants started from seeds are less tolerant of feeding damage compared to transplants, but both can be severely injured if flea beetle numbers are high.

DESIGNER DAHLIAS FOR FLORAL SALES

Katie Byler
Greystone Manor Gardens
3831 Oregon Pike
Leola, Pa 17540
greystonemanorgardens@gmail.com

Goal: To fully discuss the importance of every aspect of a dahlia's lifecycle; from tuber to bloom, farm to vase, planting , upkeep, harvesting and winterizing.

The first step to growing dahlias for floral sales is to establish your clientele. Who you are planning on selling your dahlias to, directs your thought processes while you plan your field throughout the Fall/Winter months. Wedding Florists, wholesalers, flower shops, and/or direct to consumer sales will each have different needs relative to the quantity and color of the flower blooms.

We primarily work directly with Wedding/Event florists. In our experience wedding florists prefer solid/true colors. When we grow dahlias that fall into bi-color scheme, they are difficult to sell. It is important to grow dahlias that do not open to a green/yellow center. This keeps with the solid colors for design work. There is a vast variety of dahlia selection in color, style and size (we will discuss this shortly). In regards to size, we find that a medium size dahlia (avoiding the pompon and dinnerplate varieties) allow us profitable sales at the same price point.

Staying on trend is important if dealing with florists. They strive to please their clients (brides if working with wedding florists). These clients are busy searching pinterest! We need to be there with our florists, and stay a step ahead ensuring we plant colors that are "on trend" which the florists will want in the late summer and fall. Burgundy, white, cream, and blush hold a large percentage of sales. Direct to consumer sales, flower shops, and wholesalers will need summer colors which transition into Fall colors as the seasons progress. In 2019 Pantone Color of the Year was Live Coral, which was a "Grand Slam" with dahlias. They recently released their 2020 color: Classic Blue. Since dahlias do not come in a true blue, we will look to colors that coordinate with blues beautifully.

The diversity of dahlia color and variety is quite large. Dahlias can be a 1" Pompon in comparison to a 14" dinnerplate. Collarettes, waterlily, anemone, cactus, ball, and decorative dahlias all are categories of dahlia varieties. We find that ball and waterlily dahlias have some of the best vase lives. We do plant dahlias in each category, with the exception of pompons, to provide variety.

As the weather warms and you begin to think about planting your dahlia tubers, we recommend beginning with a soil test to determine proper pH as well as any other soil irregularities. We wait until the threat of frost has passed and the ground has warmed to plant. Prior to planting, it is advisable to do some investigation to determine if there exists any soil borne insects (wireworms, ants, slugs, etc.). After tilling our ground, if not utilizing a physical weed control barrier (plastic or woven fabric), we apply a herbicide pre-plant (Snapshot 2.5G) and a 'band' a base fertilizer (10-20-20 or 0-20-20 @ 400 lb per acre). Ideal soil temperatures should maintain 52 degrees F for 48 consecutive hours for best soil planting conditions. After laying driptape (higher volume drip tape @ 8" spacing is recommended) and plastic mulch, we plant double rows with 18" between both rows and tubers. They are planted 3-6" deep. Make sure to consider pests such as rabbits, groundhogs, deer, etc. that may be enticed to use your newest crop as their buffet! At this point, the tubers do not need much watering until the green growth appears. You risk rot if they receive too much water until the growth has begun.

Katie Byler has grown dahlias for over 6 years. She follows her mother's love of flowers and enjoys sharing them with those around her. The past year she joined Claire's Blooms and worked together to grow over 2,800 dahlias. Larry and Claire have grown dahlias for over 25 years. Larry also owns and operates BioPlex Organics, a wholesale formulation and distribution company (website: bio-plex.com, eMail: bioplex@earthlink.net, phone# 800-441-3573). They develop and market proprietary BioPlex brand specialty products for the extended Green Industry. Over the years, Larry (BioPlex Organics) has formulated and perfected a special water soluble fertilizer, nutrient specific for dahlias.

Once the tubers are in the ground, we begin the work of stabilizing our crop. Some plants can grow to over 6'. The wind and weather can do a lot of damage if not properly cared for early in the Spring/Summer. We utilize heavy duty 5-6' t-posts every 12-15 feet for each row. We then encircle the posts with poly-wire. The first level of wire stands about 24" off of the ground. To the wire, we use special techniques to attach horizontal floral netting. A second level of perimeter wire and netting goes above the first, standing at roughly 18-24" above the first level. Taking time to properly stake or trellis your dahlias will avoid mid-season disaster and pay dividends in the end. When the summer storms roll through, if dahlias are not stabilized (trellis or staking) properly, they will lay over or snap off. Either way, they will not produce the quality and quantity of flowers needed for sales.

Your dahlias will exceed expectations when properly cared for throughout the growing season. Staying ahead of the weeds that escape control from herbicides and/or plastic barriers is pertinent. As the plants grow, weeds growing in close proximity to tubers are best snipped rather than pulling them. Snipping them off allows the dahlias a head start until they overpower the weeds. It also keeps the dahlia roots from being disturbed as they establish themselves – if disturbed, it can be mortal. Feeding specific nutrients(BioPlex 10-20-30 + Micro's, BioPlex 5-10-5, BioPlex ALL Ocean 332) to your dahlias should occur with their watering weekly. We irrigate at 5,000 gallons per acre weekly once plants begin to set flower buds. Proper nutrition and proper watering are critical to harvesting dahlia blooms that best enjoin and display their fullest genetic potential. Spraying of pesticides on a regular basis is also vital. Cucumber beetles, aphids, thrips, mites, Japanese beetles, and others will significantly weaken or physically damage vegetative tissues. Some growers also utilize a chiffon bag over the buds. We spray in the late evening to protect the beneficial pollinators and insects.

Giving your florists the best blooms possible, begins with your flower buckets. Make sure your buckets are clean and prepared before you cut. Always use fresh water to cut into. Cutting your blooms is best in the cool of the day. Utilize a sharp tool and cut above a leaf to allow for future growth. The more you cut your dahlias, the more they will grow and flourish. We utilize an additive to our water to better preserve and hydrate our blooms. Dahlias do not open more after they are cut, therefore they need cut in their prime. Cutting every 3 days, gives you the optimal production of your plants. It is important to stay ahead of deadheading your blooms to ensure they do not get past their prime. The nutrients and energy of your plants should not go towards dead/past tense blooms.

It is important to look ahead to next year while your flowers are in their prime this year. Take note of their production level, their stem length and strength, their durability, their color, and any other notable attributes. Take time to record, take pictures, and LABEL! Each year is a trial, striving to find the flowers that meet demand the most. Dahlias are workhorses throughout the growing season, but with the first hard frost, their time will come to an abrupt end. Thus begins the time that makes most growers think, "is this really worth it?!" After a curing period of 7-10 days after the frost, the tubers are ready to be dug out. This time period gives the plants a chance to send carbohydrates and polysaccharides into the tuber and begin to prepare it for winter storage. We cut the stems with a sharp lopper at about 5-6" above the ground. Leaving a bit of the stem gives a "handle" as you pull the clump from the dirt. Discard the stems/leaves in your mulch/compost pile. In order to dig the clump of tubers out without cutting or damaging them, we loosen the soil up around the stem in about a 24" diameter circle. When the tubers are loosened, we pull them carefully from the dirt. Make sure that you are labeling carefully. You will find that what began as a single tuber, has multiplied significantly! The winterization process takes many forms depending on the grower. Some divide in the Fall, others in the Spring. We take steps to divide in the Fall. We wash our clumps, thoroughly dry and then divide them and treat them with a fungicide. As you divide, use a sharp tool and learn to look for the eye. To have a viable tuber in the spring, you must have an eye. Once divided, dip them in the fungicide (Bravo, Cleary's 3336F, Subdue, Chipco Weatherstick) and allow them to dry. We pack our tubers for the winter in kiln dried cedar wood chips stored in 40-50 degree temperatures with low humidity. Others may use vermiculite or peat moss or even individually wrapped saran wrap; depending on preference. It is best to check your tubers monthly and adjust if needed. Remove tubers with rot so that it does not spread to other tubers. When the weather begins to warm, it is time to pull them from their winter rest and tuck them back into the ground for another year of work!

Reference: Specific details and programs relative to dahlia NUTRITION, WEED CONTROL, WATERING, TRELLIS SPECIFICATIONS and PEST CONTROL are available from Larry Hershberger, BioPlex Organics/Claires BLOOMS@bioplex@earthlink.net/ 800-441-3573

BIOCONTROL OPTIONS FOR CUT FLOWERS

Steve Bogash
Territory Business Manager, Marrone Bio Innovations

Proactive growers that pay careful attention to fine details can effectively manage most cut flower pests using a biologically-based fungicide program. Management at the level necessary to make this work well requires the coupling of good sanitation practices and active management of ventilation (for indoor production) as well as other BMP's along with the biological fungicides, insecticides, and miticides. Diseases like Downy mildew may require specific systemic materials that are outside of those considered to be biological. The practices described in this article are readily adaptable to both indoor and outdoor production across a wide variety of genus and species.

Direct application of beneficial fungi and/or bacteria to soil, potting media, and plant foliage is a practice which is rapidly catching on with producers. The methods and philosophy of using biofungicide drenches such as Actinovate AG™ RootShield Plus™ and TerraGrow™ are distinct from our past practices of starting with "sterile" media and fighting to keep it clean. We've typically fought the plant disease wars through the application of various chemical fungicides in rotation as we attempt to slow the development of resistance. With materials such as these drenches application is required prior to any suspected infection as these materials boost plants abilities to prevent infection.

Biopesticides have unique modes of action (MOA) that can provide levels of pest management not possible with our traditional fungicides, insecticides and miticides. Some are living organisms, others are plant and microbial extracts. However, they are different enough from conventional pesticides that their application requires strict adherence to the labeled application instructions. Often pH, tank mixing, and surfactant instructions are very precise in order to reach maximum efficacy. Even with these challenges, field experience has proven that these biological materials can provide pest management in situations where traditional chemistries have failed to do so. Also, since they are living or extracts from living materials, many of these biological materials have short storage lives and specific storage instructions. Consult the label and manufacturer for storage instructions and active lifespan.

How biological fungicides / bactericide work (modes of action):

Direct Competition: Before infection can occur, the pathogen must gain access to the root zone, then penetrate plant tissue. An effective biofungicide will grow faster than the pathogen and out compete it for nutrients and space.

Antibiosis: Some biological materials produce chemical compounds such as antibiotics and toxins that kill or inhibit pathogen growth. These compounds can prevent germination of fungal spores or restrict growth.

Predation and or Parasitism: Some materials such as Actinovate AG™, Root Shield Plus™, and TerraGrow™ claim that their materials actively seek out pathogens and destroy them.

Induced Resistance: While plants do not have immune systems like animals, they do have defense mechanisms. Certain biological controls such as Regalia™ will induce plants to produce defensive compounds such as salicylic acid (similar to aspirin) and jasmonic acid. These biological pathways (SAR and ISR) turn on 'levers' throughout plants that produce tougher plants, numerous fungitoxic and bacteritoxic compounds that travel throughout the plant and stimulate the plants own defense mechanisms prior to infection.

Disease Management Materials:

-Regalia™: (extract of Reynoutria sachalinensis). This material turns on a plants ISR and SAR biological pathways making for an overall tougher organism that is primed to fight many plant pathogens. This material has long been

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

the base in the authors high tunnel and greenhouse protective programs. It tank mixes well with coppers and many other materials for greatly enhanced efficacy.

-Actinovate® AG: (ai: Streptomyces lydicus) The label claims efficacy on Fusarium, Rhizoctonia, Pythium, Phytophthora, and Verticillium. Used as both a root drench and foliar material. Very effective in control of specific root-borne diseases.

-Stimplex®: (extract of North American seaweed, listed AI is kinetin, a source of cytokinens) Research indicates that Stimplex and other seaweed extracts have the potential to initiate plant defense systems as well as initiate the production of cytokinens, a hormone that can boost the initiation of blossoms.

-Stargus™: (B. amyloliquefaciens strain F727) Rhizobacterium that colonizes in the soil for Fusarium and other soil-borne disease prevention. On above ground plant, fruit and flower surfaces, lipoproteins and peptides created by the bacteria provide disease control.

-Triathlon BA™: (B. amyloliquefaciens strain D747) Very similar MOA's to B. subtillus. Lipoproteins and peptides from bacteria provide surface control for many diseases including Powdery mildews.

-Cease® (B. subtillus strain QST 713) The spent substrate and media from this bacteria coat plant surfaces preventing many diseases. Good tank mix partner with Regalia to provide additional MOA's beyond ISR.

-RootShield Plus®: (Trichoderma harzianum strain T-22, and T. virens) preplant inoculant. These specific fungus develops a symbiotic relationship with plant roots and will continue to grow with the plant. Preventative for Rhizoctonia, Pythium and Fusarium. Also enhances the uptake of many plant nutrients. Must be kept refrigerated when not using.

-TerraGrow® :(Trichoderma spp + specific bacteria). Very similar in use to RootShield plus, but with added beneficial bacteria. Claims to be shelf stable for 1 year at normal storage temperatures.

-Coppers: (Kocide®, Badge®…….) Coppers have long been used as fungicides and bactericides and are an important component of any disease management program. Of these formulations, few have an OMRI label. The primary drawback of coppers is the tendency to stain leaves and flowers. Also, increasingly bacterial diseases demonstrate a resistance to coppers. Good tank mix partners with multiple modes of action. Both Kocide and Badge have OMRI listed versions.

-Insecticidal Soaps: (M-Pede®, Kopa™ and others) potassium salt of fatty acids, warning label, 12 hour REI (mucous membrane irritant), works by perforating fungal membranes. Some Powdery mildew control, but not very helpful after inculant pressure reaches high levels, and the moisture and temperature conditions are near ideal for disease development. Also, be careful of overapplication as soap can damage leaf and stem cuticle. Very effective in managing soft-bodied insects and mites so long as coverage is complete.

Insect and Mite Management Materials

-Grandevo® WDG and CG (Chromobacterium Subtsugae strain PRAA4-1-T): Provides insect and mite management through repellency and agitation, gut disruption, and reduced fecundity. While slow to kill pests, they stop feeding rapidly, so the damage stops quickly. Good tank mix partner with Venerate and azadirachtin materials. Best efficacy is with a pH neutral spreader – sticker. Safe with beneficial insects

-Venerate™ CG and XC (Burkholderia spp. strain A396: Acts as a stomach poison, interferes in molting and degrades insects exoskeleton. Good tank mix partner with Venerate and azadirachtin materials. Best efficacy is with a pH neutral spreader – sticker. Safe with beneficial insects.

-Botanigard®, Mycotrol®, BioCeres®: (B. Bassiani): This is a living fungus that penetrates insect and mite exoskeletons through a penetration peg, then kills by spreading throughout the pest. Under ideal humidity conditions, the fungus will 'bloom' once the insect is dead and infect other insects. Not recommended with bumblebee pollinators or beneficial insects as not at all selective.

-Azadarachtin / Neem oil extracts: (Aza-Direct®, Aza-Guard™, Molt-X®,…): Provides repellency and acts as a juvenile growth hormone. Best when used with a tank partner such as pyrethrum, Grandevo or Venerate. Must be fresh as these materials degrade within a year of production. Not recommended with beneficial insects

-Oils: There are many horticultural oils on the market. Read all label instructions as there are often specific instructions based on temperature, plant stage and time of year as there is the potential to burn sensitive plant parts like flowers. Very broad spectrum and non-selective, so not useful with beneficial insects.

Our biopesticide toolbox and understanding of the best use practices for these materials continues to grow. These new modes of action are providing control for tough pests like Wester flower thrips that are now resistant to many conventional chemistries. When used with conventional materials, many make strong tank mix partners and are providing new resistance management strategies. With so many biopesticides to pull from, we can now manage many pests using solely these materials.

NEW INTRODUCTIONS AND OLD FAVORITES FOR SPECIALTY CUT FLOWERS GROWERS

Alicain S. Carlson, Ph.D.
Technical Trial Manager, Syngenta Flowers, LLC

Dr. Carlson has been with Syngenta Flowers for 4.5 years and is currently their Technical Trialing Manager. Her team is responsible for conducting research trials to validate marketing claims, build culture guides, and support Syngenta Flowers' innovative product portfolio. Before joining Syngenta Flowers, Dr. Carlson was a Postdoctoral Research Associate in the Cut Flower Research Program of Dr. John Dole at NC State University (NCSU). Dr. Carlson earned her M.S. and Ph.D. at NCSU in Horticultural Science studying various aspects of production and postharvest of several cut flower species. Her most notable contributions were to the understanding of the best production and postharvest handling practices of Eucomis (pineapple lily). Dr. Carlson also co-wrote the book "Postharvest Handling of Cut Flowers and Greens" which is available through the Association of Specialty Cut Flower Growers (ascfg.org). She found her love of cut flowers through floral design and working on a cut flower farm during college.

New Introductions

Sunfinity™ sunflower (Interspecific helianthus)

Sunfinity is unlike any other seed annual sunflower on the market. It is an interspecific hybrid that blooms and branches for 9-12 weeks. It boasts warm, golden petals and a dark center for a traditional look. Great flower size and stem length for bouquets. Perfect choice for pick-your-own farms since customers can cut flowers and the plant would re-bloom unlike one-and-done varieties that would need to be replanted. Vase life of 8-9 days; holding solution recommended.

Kirigami™ aquilegia (*Aquilega cearulea)*

Kirigami has large, upright facing flowers perfect for mixing into bouquets unlike native columbines that have flowers that hang down. Red, pink, yellow and blue flowers are available. Kirigami is a first-year flowering perennial with very minimal vernalization requirements. Vase life of 5-7 days; use holding solution.

Cambell™ Blue campanula (*Campanula rapunculoides)*

Perfect for those looking for true blue flowers! Cambell has tall stems measuring 12-16 inches lined with dainty blue star-shaped bell flowers. It has a vigorous growth habit and blooms in the summer. Vase life of 7-10 days; use holding solution. Great for high tunnel production.

Excalibur™ delphinium (*Delphinium elatum*)

Classic spikes of vibrant white, pink, and blue flowers bloom the first year. Uniform, well-branched plant habit with sturdy flower stems up to 22 inches. Excalibur has well-developed panicles with strong and stable color varieties. Use holding solution and anti-ethylene agent; vase life of 5-7 days.

Arabesque® penstemon (*Penstemon hartwegii*)

A nice alternative to a snapdragon. Comes in Appleblossom, Red, Orchid, Pink and Violet colors. Arabesque has a branching habit and strong stems from 24-30 inches long. Vase life is 4-7 days; use holding solution.

Dr. Carlson has been with Syngenta Flowers for 4.5 years and is currently their Technical Trialing Manager. Her team is responsible for conducting research trials to validate marketing claims, build culture guides, and support Syngenta Flowers' innovative product portfolio. Before joining Syngenta Flowers, Dr. Carlson was a Postdoctoral Research Associate in the Cut Flower Research Program of Dr. John Dole at NC State University (NCSU). Dr. Carlson earned her M.S. and Ph.D. at NCSU in Horticultural Science studying various aspects of production and postharvest of several cut flower species. Her most notable contributions were to the understanding of the best production and postharvest handling practices of Eucomis (pineapple lily). Dr. Carlson also co-wrote the book "Postharvest Handling of Cut Flowers and Greens" which is available through the Association of Specialty Cut Flower Growers (ascfg.org). She found her love of cut flowers through floral design and working on a cut flower farm during college.

Tried and True Favorites

Madame Butterfly™ snapdragon *(Antirrhinum majus)*

Flowers in the Madame Butterfly series have a unique "azalea type", double petal form which prevents pollination by insects, allowing flowers to last longer than single-petaled varieties. The mix contains bronze/white, cherry/bronze, ivory, pink, red, rose, yellow, and bronze blooms, and is also now available in separate colors. Madame Butterfly is suitable for outdoor or high tunnel production from spring through fall. Plants can be grown single stem when spaced closely together, or multi-stem if spaced further apart, as the plants branch well (ascfg.org). A tried and true favorite – it won the ASCFG Cut Flower of the Year Award in 2016. Vase life of 7-10 days, use holding solution.

Liberty™ Classic (*Antirrhinum majus)*

Liberty Classic boasts a shapely, central flower spike that has timeless consumer appeal. Provides a classic snapdragon look with strong, sturdy stems that stand up tall to 18-22 inches. Colors include lavender, bronze, crimson, rose pink, white and yellow and a mix. Vase life of 7-10 days, use holding solution.

Camelot™ foxglove (*Digitalis purpurea*)

Camelot has large flowers on tall stems for a dramatic display. Comes in white, cream, lavender, rose and a mix. Camelot is uniform in flowering and habit, with no vernalization required. Blooms in spring and summer on 42-48 inch tall stems. Vase life of 7-10 days; use holding solution.

Uproar™ Rose zinnia (*Zinnia elegans*)

The only color in the series, but it's beautiful! Uproar Rose boasts long stems and fully double flowers. A tried and true favorite – it won the ASCFG Cut Flower of the Year award in 2009. The ASCFG reported: 'Uproar Rose' was the highest-rated cultivar in the 2008 Seed Trials. Its consistent magenta-rose color, high degree of doubleness and large flower size made this a favorite with growers across the country. It was called a standout in the field for its heavy yield on strong 30-inch stems. For those growing zinnias in the North, one planting may be enough for long stems all season. For those in the South, fresh plantings every four weeks will insure a constant supply of high-quality flowers. 'Uproar Rose' is mildew resistant but as with similar cultivars, the incidence will increase on older plantings, especially in the fall (ascfg.org). Vase life of 7-10 days, use holding solution. Zinnias don't tolerate cold storage well.

Zowie!™ Yellow Flame zinnia (*Zinnia elegans*)

Zowie! has a striking, bright bicolor pattern that's perfect for summer and fall sales to bring a pop to any arrangement or by itself. It's vigorous and well-branched with fully double flowers. Vase life of 7-10 days, use holding solution. Zinnias don't tolerate cold storage well.

HYDRANGEAS FROM FIELD TO VASE

Thomas G. Ford
Penn State Extension
401 Candlelight Drive, Suite 220
Ebensburg, PA 15931
Email: tgf2@psu.edu

There are many woody ornamentals that can be used for the florist trade, but there are very few genera that can surpass Hydrangeas for both their intrinsic beauty and utility as both a fresh and dried flower. Hydrangeas in general are large multi-stemmed shrubs that can be found in many shrub borders and home landscapes in the Mid-Atlantic region.

The most popular hydrangea utilized by florists is *Hydrangea macrophylla* which is also known as the "Bigleaf Hydrangea". *Hydrangea macrophylla* is a native to Japan and is considered hardy from Zone 6 to 9. Unfortunately, winter weather extremes can kill the flower buds of some cultivars (which bloom on old wood) resulting in no blooms or few blooms for the flower grower. The selection of "remontant" cultivars like 'Endless Summer" however which bloom on old and new wood ensures a beautiful floral display each season. Specialty cut flower growers wishing to have a consistent yearly supply of hydrangea flowers for their market should only grow "remontant" cultivars in field settings. 'Remontant' hydrangea cultivars of merit include 'Endless Summer', 'Blushing Bride', 'David Ramsey', 'Penny Mac', and 'Oak Hill'.

Hydrangea macrophylla flower color can typically range from blue to pink depending on cultivar and when it is harvested. Flower color of the "Bigleaf Hydrangea" is determined by the amount/availability of aluminum in the soil. Aluminum availability in the soil increases as the soil pH decreases. Growers that want blue flowers should adjust the soil pH to 5.0 and add aluminum. Growers wishing to market pink flowers should adjust the soil pH to 7.0 with lime and should add additional phosphorous as well. Soil pH levels residing in the middle (about 6.0) will tend to have stronger mauve to purple hues.

Hydrangea macrophylla is spaced 3' x 5' by most cut flower growers and will yield a minimum of 15-30 stems per plant (cultivar dependent). *Hydrangea macrophylla* can be harvested in the fresh stage when the colors are bright and clean or in the classic stage as the colors tend to fade and take on a stronger green or brownish hue. If appropriately handled *Hydrangea macrophylla* flowers will have a vase-life of 4-9 days. Hydrangea macrophylla can also be dried to extend the sales window and can be dyed using Rit dye.

Hydrangea arborescens which is known as the "Smooth Hydrangea" is one of the more popular hydrangeas for weddings with its clean, bright white flower color. *Hydrangea arborescens* bears its flowers on new growth so it will bloom reliably each season. *Hydrangea arborescens* flowers appear bright green as they emerge and can be harvested in this less mature stage to meet the design intentions of some florists and decorators.

Hydrangea arborescens can be grown in USDA Hardiness Zones 3-9 and is frequently spaced 4' x 5' by most flower growers. Yield per plant can average 12-15 stems per plant with a vase-life of 4-9 days. *Hydrangea arborescens* can also be dried and dyed to extend the market window and to provide interior decorators with a range of color schemes for indoor usage. *Hydrangea arborescens* cultivars of merit include:

Tom Ford has worked for over 37 years with Cooperative Extension in Maryland, North Carolina, and Pennsylvania. Prior to starting his Extension career Tom worked in the landscape and greenhouse industry and grew vegetables for sale at a local farmers' market in Westminster, MD. Throughout his Extension career Tom has worked extensively with vegetable, fruit, greenhouse, and nursery growers and has also assisted green industry professionals with their insect, disease, and weed management problems.
Tom is a native of Central Maryland and resides with his wife, Laura in Duncansville, PA. Tom has a B.S. degree in Ornamental Horticulture from the University of Maryland and a MBA from Frostburg State University in Frostburg, MD. Tom currently serves as a Commercial Horticulture Educator with Penn State Extension and is housed in the Cambria County Extension Office in Ebensburg, PA.

'Annabelle'- Rounded shrub 3-4' in height with a similar spread. Flowers emerge green and turn to a clear bright white. Floral inflorescences can be over 12" across.

'Bella Anna" – Similar to 'Annabelle" but slightly smaller with pink flowers.

'Incrediball' – Considered to be superior to 'Annabelle" reaching 4-5' with creamy white 12" ball-shaped flowers on strong stiff stems.

'Invincibelle Spirit' – Dark pink buds open to produce a large 6-8" rosy pink flower cluster that turns a soft pink as it ages. Recommended for drying.

'Hayes Starburst' – Produces white double flowers in clusters that resemble a starburst. Approximately 2-3' in height.

Hydrangea paniculata which is also known as the "Panicle Hydrangea" is fast becoming the most popular of the hydrangea species being grown by Mid-Atlantic cut flower growers. Hydrangea paniculata can be grown successfully in USDA Hardiness Zones 3-8. Growers typically space the plants 3-5' apart in the row and 10-12' feet between rows. *Hydrangea paniculata* can be sold fresh or dried and can have a vase life of 6-14 days. Yield per plant can be variable depending on pruning techniques and cultivars but yields of 20-30 stems per plant have been observed. *Hydrangea paniculata* flowers on new wood so growers can prune it back hard in the winter (about 3' tall) to yield 3-4' stems with 6-8" long inflorescences. Many growers also thin the plant to 5 stems to ensure a robust floral display. *Hydrangea paniculata* cultivars of merit include:

'Grandiflora' – Large shrub to small tree reaching a height of 10-20' with a width of 10-15'. Rounded flower clusters are white and somewhat pendulous. Flowers age to pink and brown tones on the plant as they mature.

'Limelight'- Mounded form 6-8' in height with a similar spread. Flower inflorescences start creamy white and then go from lime green to rosy pink and finally to tan.

'Pink Diamond' – Upright habit 10-15' high with an 8-10' width. Flowers open white and gradually turn a dark pink progressing from the base of the panicle upwards.

'Pinky Winky' – Compact plant about 6-8' in height. Flower clusters are white and conical in appearance before turning pink from the base upwards which gives them a two-toned appearance.

'Quick Fire' – Mounded form that is 6-8' high with a similar spread. Flowers emerge white and then turn to a deep rich pink

'Tardiva' – One of the last hydrangeas to bloom. Flowers go from white to purplish pink as they age. Fast growing 10-15' high with a similar spread.

Postharvest Handling of Hydrangeas

Hydrangea hydration after cutting is a major problem for many cut flower growers. Hydrangeas are cut and defoliated in the field. Many growers leave the top or uppermost leaves on the stem after harvest. After harvest, the stems should be placed in warm water (100^0 to 120^0 F) or a hydrator immediately after cutting. If there is any delay in placing them in this solution growers should immediately re-cut the stems about once inch from the bottom before placing them in the warm water solution. Next, the grower should transfer the stems to a clean container containing a floral preservative solution. Once in the solution the stems should be placed in a cooler (34-50^0 F) for approximately eight hours until the hydrangeas are to be packaged and shipped.

Research has shown that hydrangea vase life can be extended by increasing the EC (Electrical Conductivity) of the water. The use of floral preservatives increased vase-life the vase-life of hydrangeas from a low of 4.5 days with just plain water to 10.6 days with a floral preservative. Increasing EC increased vase-life from a low of 3.5 days to a high of 5.7 days at 4.0 dS/m in water and from a low of 7.3 days to a high of 15.4 days at 2.5 dS/m when floral preservatives were used. Low solution pH coupled with a moderate EC and the use of floral preservatives has been shown to significantly extend the vase-life of hydrangeas.

Fresh cut hydrangeas must be stored wet while antique flowers can be stored dry. Hydrangea stems can be shipped in plastic-lined boxes wet or dry. Upon receipt by the florist fresh-cut stems should be re-cut and then placed in warm water before their placement in the cooler.

References

Ahmad, I., J. Dole, A. Carlson, and F. Blazich. 2013. Water quality effects on postharvest performance of cut calla, hydrangea, and snapdragon. Scientia Horticulturae 153:26–33.

"Big-Leaved Hydrangea." *Big-Leaved Hydrangea | The Morton Arboretum*, https://www.mortonarb.org/trees-plants/tree-plant-descriptions/big-leaved-hydrangea.

Greer, Lane, and John M. Dole. *Woody Cut Stems for Growers and Florists: Production and Post Harvest Handling of Branches for Flowers, Fruit and Foliage*. Timber Press, 2009.

"Panicled Hydrangea." *Panicled Hydrangea | The Morton Arboretum*, https://www.mortonarb.org/trees-plants/tree-plant-descriptions/panicled-hydrangea.

"Wild Hydrangea." *Wild Hydrangea | The Morton Arboretum*, https://www.mortonarb.org/trees-plants/tree-plant-descriptions/wild-hydrangea.

HYDROPONICS 101 - WHAT YOU NEED TO KNOW ABOUT HYDROPONICS

Chieri Kubota
Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210

Hydroponics is a growing method of using nutrient solution without soil under **controlled environmen**t (high tunnels, greenhouses and indoor farms). It is also considered synonymous to soilless culture in the United States, although hydroponics may have a more strict meaning as 'liquid based culture' or 'water culture' and excludes soilless (substrate-based) culture.

Some history. We know that the US military effort (or desire to eat fresh vegetables) during World War II contributed to developing the technology to apply in remote islands or an occupied country whose people do not traditionally have the culture of eating fresh (uncooked) vegetables. Early hydroponic operations in these situations were outdoors or under minimum protection (screen/shade) and later hydroponics was introduced to the controlled environment technology of greenhouses that extended the crop production season. Worldwide, hydroponic greenhouse crop production is a fast-growing industry sector. Hydroponics approach eliminates the need of soil management, allowing intensive production using the same land. Therefore, it is considered suitable for applications in area where arable land or poor soil is the limitation. Liquid based culture system allows 100% recirculation of nutrient solution, which is a standard technology of the industry today.

Crops suitable for hydroponics. Many crops can be grown hydroponically. However, whether it makes economic sense or not depends on the productivity and value of the crop. In North America, tomato has been the most widely grown crop using hydroponics (soilless culture). Other crops grown hydroponically include cucumber, sweet pepper, leafy greens (lettuce, kale, herbs, other leaf vegetables), medicinal herbs, and strawberries.

Growing systems. There are **three different types of systems** commercially used in hydroponics. First, it is a system called '**NFT – Nutrient film technique**'. This system was originally invented in England and is probably the most commonly applied for leafy greens in the US today. Plants are grown in rows of shallow NFT channels (troughs) with continuous flow of nutrient solution. Plants' roots are in contact with this thin film of nutrient solution inside the channel. The next system is a '**DWC – Deep water culture**' or sometimes called also 'DFT – Deep flow technique' or 'Floating raft culture'. This system was reportedly invented by Dr. Merle Jensen at the University of Arizona and plants are grown on floating polystyrene panels with roots completely submerged in the nutrient solution that is constantly aerated for oxygen. Both NFT and DWC are suitable for leafy greens. For fruiting vegetables such as tomato, cucumber, and pepper, and small fruits such as strawberry, soilless substrate culture with drip irrigation on metal gutters is a common system to consider. Tall crops like tomato are typically supported by vine twine hanging from a steel cable placed at the greenhouse gutter height. For this reason, this production system is also known as 'high-wire production method'.

Nutrient solution. Regardless, nutrient solution used for hydroponics (with or without substrates) must include all 13 micro and macro elements needed by plants. Electrical conductivity and pH of nutrient solution are two important parameters and growers must maintain these values to stay within the acceptable range. Otherwise, plants may show nutrient deficiency, toxicity or other physiological disorders and the yield is reduced. Pre-mixed fertilizers suitable for hydroponics are also commercially available; however, growers who have recirculation system

Dr. Chieri Kubota is a professor in the Department of Horticulture and Crop Science, the Ohio State University. Dr. Kubota received Ph.D. in Horticultural Engineering and M.S. in Horticultural Science from Chiba University, Japan. Dr. Kubota worked as faculty for 6 years in Chiba University, 16 years in the School of Plant Sciences at University of Arizona and recently (in 2017) joined the faculty at the Ohio State University. Her research program focuses on the development of science-based technologies in the area of controlled environment agriculture (CEA). Dr. Kubota's research includes value-added CEA crop production, vegetable grafting, hydroponic strawberry production, as well as LED lighting applications

are recommended to mix their own salts to maximize the flexibility to do fine-tuning of elemental concentrations (ppm) on a weekly basis.

Photos: Various hydroponic systems used commercially in North America. (Upper left) DWC system for lettuce production, (Upper right) soilless culture with drop irrigation for strawberry, (Lower left) NFT system for basil, and (Lower right) high-wire, soilless culture with drip irrigation for tomato.

GROWING GREENHOUSE STRAWBERRIES

Chieri Kubota
Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH 43210

Substrate-based strawberry production under controlled environment (greenhouse, high tunnels) is a fast growing sector in North America. Along with the increasing interest in local production, several greenhouse industries as well as traditional field producers in North America began to produce strawberries under controlled environment. Production systems range from Dutch-style Venlo greenhouses (for year-round production) to single layer polyethylene tunnels with 'table top' production systems (for extended seasonal production). This presentation will review key greenhouse technologies that enable off-season production of strawberries in the United States. Complete information on the basics and applications of growing strawberries under controlled environment can be found in our indoor-berry website (www.u.osu.edu/indoorberry).

Planting Materials and Cultivars. Strawberry is vegetatively propagated, typically with daughter plants developed on runners (stolons). Cultivars are classified as June-bearing type (short-day plant) and ever-bearing type (facultative long-day plant). Cultivars conventionally classified as "day-neutral" type also behave like facultative long-day plants. There are a small number of 'seed-propagated' strawberry cultivars, although their commercial applications are still limited. There are various types of transplants available for strawberry production. They are bare-rooted frigo plants, fresh dug plants, runner tips, rooted runner plugs, and tray plants. However, off-season producers have relatively limited options in North America, due to the fact that availability of specific types of planting materials are seasonal and optimized for existing open field cropping systems. Also growers new to strawberry must understand that many cultivars available in North America are proprietary, which requires an appropriate license agreement to propagate even for their own usage. Therefore, growers need to purchase transplants from a nursery who carry the propagation license of the selected cultivar.

Production systems. Controlled environment structures for strawberries grown commercially use distinct types of structures, including 1) High tunnels (AKA table-top systems), 2) Greenhouses, unheated, 3) Greenhouses, heated, and 4) Indoor farms (without sunlight). Soilless substrate-based production system with drip irrigation is the most widely used production system commercially. Productivity seems to be limited in water-culture-based production systems. Regardless, production systems are designed so that workers stand instead of bending over the crops, improving worker efficiency.

Soilless substrate-based production system using a simple raised gutter supported by a leg structure anchored in the ground is called 'table-top system'. Table-top systems are typically placed inside a simple structure such as rain shelters or high tunnels. This system is widely used in Europe and is slowly being introduced in North America. In temperature controlled Dutch-style greenhouses, use of steel hanging gutters similar to those used for high-wire production is common. A typical spacing between gutters is 3.3 feet (center-to-center), shorter than a standard high-wire spacing (5 feet). Placed on top of the gutters, containers and bags filled with soilless substrates are irrigated with drip irrigation systems.

Substrates and nutrient solution. Strawberry plants are very sensitive to root zone environment (physical and chemical environment). Their roots do not develop well when inappropriate substrate is used or moisture content is

Dr. Chieri Kubota is a professor in the Department of Horticulture and Crop Science, the Ohio State University. Dr. Kubota received Ph.D. in Horticultural Engineering and M.S. in Horticultural Science from Chiba University, Japan. Dr. Kubota worked as faculty for 6 years in Chiba University, 16 years in the School of Plant Sciences at University of Arizona and recently (in 2017) joined the faculty at the Ohio State University. Her research program focuses on the development of science-based technologies in the area of controlled environment agriculture (CEA). Dr. Kubota's research includes value-added CEA crop production, vegetable grafting, hydroponic strawberry production, as well as LED lighting applications.

not managed well. Strawberry fruit yield is therefore largely affected by substrates and resulting rootzone conditions. Physical characteristics interact with container geometries. This means that substrate optimization/selection must take a whole system approach. Optimizing substrate physical, chemical, and biological properties can increase the overall yield of strawberry by ~30% per our recent study at the Ohio State. When pre-mixed substrates are used, it is important to understand that what is an optimum substrate depends on the climate conditions (potential transpiration), container systems (column height and drainage design) and source water quality (e.g., alkalinity).

Irrigation (fertigation) is a key management technique in high quality strawberry production. At the Ohio State, we typically use a Japanese nutrient formula which has relatively low nitrogen concentration (77-100 ppm with 90% in nitrate form). Electrical conductivity is maintained at 1.0 dS/m and pH is adjusted between 5-6. Strawberry plants require good porosity and drainage to assure good oxygen availability in the root zone.

Environmental conditions and benchmark yield. Strawberry plant responses to environmental conditions are a complex topic. Responses to specific cultivars need to be examined on site, rather than simply applying this general literature-based information. Especially those cultivars that are bred for and cultivated in open fields, there is little information regarding responses to individual environmental factors (and their interactions). Greenhouse controlled environments allow independent control of photoperiod, light intensity and temperature among other factors, and thereby potentially control the plant growth and development to maximize the crop productivity and fruit quality. When all conditions are in optimum ranges, strawberry production is highly correlated with light and plants seem to produce 2-3 grams of fruit per every addition of one mole of photosynthetic active radiation (mol m-2). With good light and optimum environment, benchmark yield can be 700 grams to 1 kg (1.5 to 2.2 lb) of fruit per plant over 6-7 months of off-season production (e.g., early November to May). Productivity is also depending on cultivar. However, highly productive cultivar tends to have less flavorful fruits (lower Brix or soluble solid concentrations).

QUALITY AND STORAGE LIFE OF BERRIES

Penelope Perkins-Veazie
North Carolina State University, Plants for Human Health Institute, Department of Horticultural Science
600 Laureate Way, Kannapolis NC 28081
Penelope_perkins@ncsu.edu

For berries, appearance promotes purchase and flavor bring repeat sales. Larger size, freedom from decay or injury, and attractive, full color are appealing to consumers. Good flavor, especially high sweetness/low sourness, and the characteristic key smell or taste (such as recognized strawberry or raspberry flavor) keeps consumers eating the berries.

Berries differ from many other fruits because they lack a protective rind or thick cuticle. Also, most of the small fruits gain sweetness only from the plant and must be picked at or close to full ripeness, when they also are soft. The combination of soft fruit high in sugars and lacking a cuticle makes these fruit very vulnerable to fungal decay.

Before planting small fruits, decide first what your market will be. Labor availability and control of the insect spotted wing drosophila (SWD) are major concerns for growers in most of the U.S. U pick operations may offer a means of dealing with a labor shortage and SWD but fruit genetics, containers, and refrigeration needs will differ from direct or wholesale markets.

Genetics

Flavor depends both on the genetics of the fruit and the environment (water, light, temperature). Warm sunny days and cool nights promote sugar accumulation while rainfall or irrigation close to harvest can dilute the sugars. Fruit color is highly dependent on genetics and environment. Raspberries and strawberries may look too dark or overripe if grown where air temperatures are warm and the genetics of the variety tend to be for more pigment production. In contrast, lower pigment berry varieties may not get sufficient color and look unripe if grown in cooler temperatures. High tunnel production and harvest may be easier if a caneberry is more upright or known for larger berries. Firmness and size are genetically inherited. Blueberries and blackberries have varieties well recognized as being more firm or less firm. Less firm varieties can work well in U-pick but will not survive transport to far markets. And some varieties will ripen earlier than others. This can be important when looking at late frosts, peak SWD periods, peak market windows, or rainfall and increased decay periods. So check with nurseries or extension programs to see what varieties will survive best in your area and also which have the fruit characteristics you want. Many small fruits are perennial crops, needing a 5 year investment period; sometimes planting a range of varieties works well to figure out what works best and to help offset production costs.

Harvest and handling

Practice GAPs (good agricultural practices) in your fields. Make sure water used for irrigation or hand washing is potable and animal introduction (deer, geese etc.) is minimal. As berries can heat up quickly on sunny days in mid-summer, try to pick early, before noon, to reduce field heat. Plan to train workers or guests on the correct way to detach fruit to avoid fruit bruising or plant damage. Make sure obviously injured and decayed berries are not in the containers. Choose containers prior to harvest and make sure they are new, not recycled, and clean, not dusty. Most small fruit are picked into vented plastic containers (clamshells) for commercial sales, and usually a half pint is used for raspberries, a pint to

Penelope Perkins-Veazie is a research professor in horticulture at the Plants for Human Health Institute at the North Carolina research campus in Kannapolis NC. She works with storage technologies, shelf life extension, and phytochemicals in fresh fruits and vegetables. Dr. Perkins-Veazie is a native of Maine and has a B.S. in plant and soil sciences from the University of Maine at Orono with a M.S. and PhD in horticulture from the University of Florida. Dr. Perkins-Veazie worked for USDA-ARS as a Postharvest Plant Physiologist in Lane, Oklahoma prior to joining the NCSU faculty.

quart size for blackberries and blueberries, and quart size for strawberries. Fruit are generally picked in the field for final sales, although blueberries are sometimes washed and sorted in the packhouse. Additionally, the design/size of container selected may be decided by the commercial marketer so be sure to check on this as you don't want the wrong size or style of clamshell on your hands.

Cooling and refrigeration

Temperatures below 41° F are critical to delay growth of gray mold (*Botrytis cinerea*), which attacks all small fruits and can make a pack of fruit unmarketable within hours. Removal of field heat must be done quickly, within an hour or two of harvest as delayed cooling can make fruit softer and more vulnerable to fungal growth. For small fruit, this is done by forced air and/or room cooling. Forced air is done by placing fruit in a cold room (32-41 °F). Pallets of fruit are set up in two lines on each side of a fan and a tarp placed over the top of the fruit. This creates a tunnel and slight negative vacuum when the fan is turned on and allows the warm air to be pushed/pulled from the fruit. This type of cooling can bring fruit temperatures down to 40 F within an hour compared to room cooling which may take 6 hours if the harvest temperature was warm (above 70 °F). Once the berries are cooled, hold them cold (32-40 °F) and try to make sure that they are transported cold. Warming the fruit can reduce shelf life in half.

Coolers

Cold rooms can be purchased pre made or adapted from shipping containers or built from scratch. The classic cold room is similar to that used by restaurants, but should have a larger condenser unit and evaporative capacitor to keep relative humidity higher (near 80%). Many growers have started using cool bot technology, which essentially fools a digital AC unit into putting out cold air to temperatures well below the usual 60 F cut off. Loan programs are also available for more energy efficient cold rooms through USDA.

Resources

There are a lot of resources on line for postharvest guidance, including extension and government publications, and also some commercial sites/blogs. These are provided below:

Crop specific postharvest fact sheets

USDA Handbook 66 https://www.ars.usda.gov/ARSUserFiles/oc/np/CommercialStorage/CommercialStorage.pdf

UC Davis postharvest fact sheets

http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/

General pre and postharvest and produce industry information

The Produce Nerd https://www.theproducenerd.com/

Storeitcold.com https://www.storeitcold.com/post-harvest-vegetable-care-on-the-farm/

NC Center for Environmental farming systems https://cefs.ncsu.edu/food-system-initiatives/nc-growing-together/resources/#producers

Information on refrigeration and types of coolers

Cool bot and prebuilt coolers https://www.storeitcold.com/

USDA REAP program for energy efficient cooler funding/loans https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency

USDA-FSA (Farm Service Agency): makes loans and microloans for cooling, cold trucks (2016). See: https://www.fsa.usda.gov/programs-and-services/price-support/facility-loans/farm-storage//

Premade small trailers with cooling systems

NCSU's pack n cool trailer building guide https://plantsforhumanhealth.ncsu.edu/2012/08/20/pack-n-cool/

Forced air cooling for berry crops https://rvpadmin.cce.cornell.edu/uploads/doc_101.pdf

WHAT TO DO AFTER A HAILSTORM

Quick Action By Growers Can Reduce Losses In Fruit Plantings Damaged By Storms.

Mark Longstroth
Michigan State University Extension, Small Fruit Educator

Strong storms are not uncommon. These storms often have high winds, heavy rains and even hail. Severe storms, especially accompanied by hail, have the potential to spread serious diseases in many fruit crops. There is a very short window for protecting plants after a hailstorm. Freshly injured tissue is often very susceptible to disease, especially pathogens that need wounds to infect plants. Sprays to stop diseases need to be applied immediately after the storm. After a day or two, injured tissues have died and dried out and are no longer susceptible to infection.

Injured tissue is walled off as it dies. A dry, corky layer forms, which is relatively impervious to infection. The initial period after the injury is when diseases become established on injured tissue and then spread to healthy tissue. Effectiveness of protectant sprays drops off rapidly as time passes after the injury. Close to harvest, damage to ripening fruit is the primary concern. Truthfully, there is little that can be done for injured fruit. You are protecting undamaged fruit from diseases that might start on the damaged fruit and spread to other fruit. In perennial crops damage to the plant itself is also important. Damage to the woody parts of the plant may be severe after hard hailstorms and in these cases, the focus is on preventing or reducing long-term damage.

My general recommendation is to apply a broad-spectrum systemic fungicide as quickly as possible after a damaging storm. Adding a protectant fungicide to the mix broadens the effectiveness of the spray. If the shoots and leaves are damaged, measures to protect the plants themselves may be needed. Here are some specific recommendations for different fruits damaged by hail.

In grapes, unless the vineyard was directly impacted by hail, no special measures should be needed. Where there was hail, a fungicide will reduce fruit rots and help damaged stem tissues heal. On varieties susceptible to Botrytis bunch rot, sprays to prevent this disease should be applied whenever the fruit is damaged. If the shoots and vines are damaged, crown gall may appear. There are no sprays to control crown gall, but growers should scout for it and remove it in the dormant season.

In blueberries, unless the field was damaged by hail, no special measures are needed. Where there is hail damage to the shoots and canes, fungicide sprays targeting Phomopsis canker and twig blight should be applied to protect fresh wounds from infection.

I**n bramble**s, where there was hail, growers should spray to control cane diseases with a broad-spectrum systemic fungicide.

I**n cherries**, brown rot is the main concern. Sweet cherries are always susceptible to brown rot, but they become very vulnerable close to harvest. Rain often cracks sweet cherry fruit, making them especially vulnerable to brown rot. In sweet cherries, sprays to reduce the spread of brown rot should be applied after a hailstorm if the trees were not recently treated for this disease. Many growers include sulfur products to dry out wounds in the fruit quickly. Tart cherries not as susceptible to brown rot, but become susceptible as the fruit ripens so controls are needed before harvest. Wind whip is damage to the skin of the cherry caused by abrasion during the storm. Nothing can be done with wind whip except drying out the damaged fruit and limiting disease infection to the damaged fruit.

I**n apricots,** peaches and plums that are close to harvest also need to be protected from brown. Sulfur is used on

Mark Longstroth is a Small Fruit Extension Educator for Michigan State University Extension. He has worked in the fruit industry since 1978. He began working for MSU Extension in 1994 and has over 25 years' of Extension experience working in the Michigan fruit industry. Prior to 2010, he covered all tree fruit, grape and berry crops in Southwest Michigan. Mark now focuses on blueberries, grapes and other berry crops. His main education efforts are in crop production, pest management and farm financial management. He has developed cost of production budgets for blueberries and other fruit crops. Mark is especially interested in the impacts of weather and climate on fruit production. Mark's wants to help growers remain profitable and adapt to changes in agriculture.

peaches and plums to dry out fruit wounds quickly. Do not use sulfur on apricots, which are very sensitive to sulfur. Peaches may also need to be protected against bacterial spot. Antibiotics are used against bacterial spot rather than copper after the trees have leafed out.

Copper is often used to protect against bacterial diseases of tree fruit, such as bacterial canker in cherries, bacterial spot in peaches and plums and fire blight in apples and pears. Early-season hailstorms that damage the tree should be treated quickly with copper materials. During the growing season, only tart cherries should be treated with copper. Do not use copper on stone fruits other than tart cherries when there are leaves and fruit present.

I**n apples and pears,** fire blight is a major concern. Orchards with a history of fire blight or with active fire blight symptoms should be sprayed to prevent the further spread of the disease after severe storms. The trauma from high winds, hard rain or hail creates openings in the plants that the fire blight bacteria can enter. Widespread severe storms can spread fire blight widely.

When there is significant fire blight in the area, highly susceptible varieties need to be protected after a storm. The general recommendation is to use streptomycin, which is an effective material with back action of one to two days. Streptomycin should never be used where there is resistance. This only makes things worse by removing all bacterial competition.

Other antibiotics are less useful. Kasumin is only used during bloom. Oxytetracycline is a protectant and not as useful after a trauma event. Some growers use copper or hydrogen peroxide to protect apple wounds after a hail event. After a hail storm, part or all of the crop is damaged and will be unsaleable as fresh fruit. Hail-damaged apples are often sold for juice. So, fungicides to control fruit rots are important

GROWER INNOVATIONS IN STRAWBERRY PRODUCTION

John Saylor
Saylor's Farm

A. Discussion of progression over the years of how we personally have grown our crop of strawberries. From traditional to hydroponics. Successes and failures,including:

1. Traditional growing from the past.

a. hand picking and trials with labor
b. using machinery, such as picking machine
c. constant weather and pest difficulties
d. weeding by machine , hand or experimenting with geese.

2. High tunnel production

a. favorite varieities, Albion
b. NFT pipes used with polybags filled with perlite
c. nutrients fed via small pumps
d. Thermodynamics in high tunnel strawberries. Energy is lost from the water and dissipated
e. high tunnel construction
f. weather effects on high tunnel crop
d. future outlook

3. Open discussions, question and answers

John Saylor, owner of Saylor's Farm, is an Agriculturalist from Sligo, Pennsylvania who got his start as a strawberry grower in 1960. What started out as a side hobby soon turned into a thriving business. Since his start, Saylor has ventured into other crops such as apples, blueberries, tomatoes, and many other fruits and vegetables. He and his son, Mark Saylor, have also added their woodcraft business, producing a variety of wooden boxes and bins for farm use. Saylor is always looking to push the boundaries of farming and has successfully implemented hydroponics into their business. Since experimenting with hydroponics, Saylor grows strawberries, pickles, lettuce, and herbs in their water systems.

UNDERSTANDING SPRING FROSTS AND FREEZES

Mark Longstroth
Michigan State University Extension, Small Fruit Educator

What is heat? Heat is energy and one way we measure heat is with temperature. There are three ways that heat, or energy is transferred from one object to another. One ins by radiation. Heat is radiated away from an object. You can feel this with your hand. You can feel heat from a fire or sense how cold it is outside a window. Another is by conduction. Heat moves through an object. The third way heat moves is by convection. Warm objects rise. So warm ground will warm the air above it and the warm air will rise and a cool breeze will flow to replace the rising air.

Frosts and freezes are not the same thing. A frost is when we get a visible frost. A freeze is when the air temperature drops below freezing. Sometimes we get frost when the temperatures are above freezing, and we often have a freeze without frost. It all has to do with the amount of water in the air.

There are two different ways to measure humidity, the amount of water vapor in the air. We usually use relative humidity. The relative humidity measures how much water vapor is in the air compared to the how much water vapor the air can hold. When the air is saturated the relative humidity is 100%. Warm air can hold more water than cooler air. During the day and night, the relative humidity changes as the temperature rises and falls. If the temperature falls far enough the amount of water in the air is more than the air can hold at that temperature. The air is saturated and water vapor in the air condenses as water and we have dew or frost.

The dew point measures the absolute amount of water in the air. It is the temperature at which the air is saturated, and the relative humidity is 100%. For a given volume of air, with a set amount of water vapor in it, the relative humidity varies with the temperature, but the dew point is always the same.

What does that have to do with frosts and freezes? If the dew point is much above freezing a freeze is unlikely. If the dew point is below freezing, then a freeze is more likely. Dry air heats and cools much more quickly than humid air. Water vapor in the air acts as a heat reservoir absorbing heat. The air temperature falls rapidly in dry air. As the temperature approaches the dew point the rate slows and then stops at the dew point. For the temperature to fall any further water needs to condense out of the air as dew or frost. When the water vapor condenses it gives up heat to the air and the surface it condenses on. We often see a temperature rise at the dew point. After reaching the dew point the temperature falls slowly as more and more water vapor is condensed out of the air. The dew point often tells us how low the temperature will go at night.

With a dry air mass, a freeze is more likely. Dry air has a low dew point and a low relative humidity. It warms quickly during the day but cools quickly at night. If we have clear calm conditions the ground cools rapidly at night, radiating heat away to the open sky. If we have a cloudy sky, the clouds capture the heat and radiate it back to the ground. As the ground cools, it cools the air above it. If it is windy, the cool air is mixed with warmer air above and the warmer air warms the ground. In calm clear conditions, the ground continues to cool. The ground becomes colder than the air and chills the air above it and we build up a thicker and thicker layer of colder and colder air. This type of freeze is called a Radiation Freeze. Generally, we have some options to reduce the effects of a radiation freeze.

Sometimes we have freezes with windy conditions. This is caused by the movement of a cold air mass with subfreezing temperatures. These freezes are called Advective or Wind freezes. There is little you can do about a wind freeze. Most of the freezes that cause problems in the spring are radiation freezes. These freezes occur with the passage of a

Mark Longstroth is a Small Fruit Extension Educator for Michigan State University Extension. He has worked in the fruit industry since 1978. He began working for MSU Extension in 1994 and has over 25 years' of Extension experience working in the Michigan fruit industry. Prior to 2010, he covered all tree fruit, grape and berry crops in Southwest Michigan. Mark now focuses on blueberries, grapes and other berry crops. His main education efforts are in crop production, pest management and farm financial management. He has developed cost of production budgets for blueberries and other fruit crops. Mark is especially interested in the impacts of weather and climate on fruit production. Mark's wants to help growers remain profitable and adapt to changes in agriculture.

cold front bringing a mass of cool dry air. Usually there is a stormy period as the cold front moves through followed by clearing and light winds. During the night the ground cools and chills the air above it. This layer of cold air is close to the ground with warmer air above it. Normally warmer air is located close to the ground and the air temperature falls as you rise upward. In a radiation freeze this is reversed. Cold air is located close to the ground with a warm layer above it. This warm layer is called an inversion. Wind machines are used to protect fruit plantings by mixing the warm air above with the cool air close to the ground. The effectiveness of the wind machine depends on how close the warm air layer is to the ground. Often you will hear that the inversion is high or weak or low or strong describing the relative height of the inversion and the difference in air temperature. The lower and stronger the inversion, the more effective a wind machine will be in protecting against a freeze.

Long ago when fuel was cheap, orchard heaters were used to heat fruit plantings. They heated the plants by radiation form the hot pots. Fuel prices are now prohibitive for stationary heaters, but I do get calls from growers asking how many hay bales they need to burn to heat their orchard or vineyard. We also see heat dragons advertised to growers where a portable heater is mounted on a tractor and driven thought the field to heat the plants. These machines can be effective in small plantings where the machine returns to the same place every minute or so.

Another effective way to add heat to a planting is to use sprinklers. We cover the plant in ice and keep the ice wet and maintaining the temperature of the plant inside right at freezing and preventing injury. Remember that when water vapor condensed from the air it gave up heat. Water also gives up heat when it changes from a liquid to a solid. This heat warms the ice and the plant inside. As long as we keep the ice wet, we keep the ice at 32F the freezing point of water. Fruit flowers can withstand temperatures down to 28F in the spring during bloom. We can protect the fruit and the flowers by making ice and keeping it wet. The low temperature that we can protect to is a function of how much water we can apply. For irrigation systems that apply 0.1 to 0.12 inches of water an hour we can protect to about 25F. To protect to lower temperatures, we need to apply more water. There is a danger if the temperature goes colder than we can protect. The ice dries out and the ice begin evaporating directly into vapor. This draws heat out of the ice and cool the plant rapidly. This can cause more damage than if the system was not used at all. So, the decision must be made whether to turn the system on at all because once you turn it on you need to leave it on. The sprinklers also need to be turned on before the temperature gets close to freezing as the cooling of the water and evaporation to water vapor will take heat out of the system and suddenly drop the temperature several degrees.

Sprinklers are also used in orchards under the trees or under wind machines to release heat as the water freezes warming the orchard air. These freeze control measures can work well under the calm conditions of a radiation freeze. Since the sprinklers are located below the fruit this system will not damage the plants if the ice freezes and dries out.

There are passive measures we can use to reduce freezing injury. Most of these have to do with storing more heat in the soil. The more water in the ground the more heat it can store, and this also raises the relative humidity in the planting. Bare ground can absorb more heat during the day and has more heat to lose at night. Freshly tilled soil does not store as much heat as packed soil because it has lost its connection with the lower soil so heat transfer to the surface is disrupted. For this reason, I tell growers the worst thing you can do before a freeze is till the soil. Freshly tilled soil is actually several degrees colder than packed soil.

Where there is a significant slope you can take measures to improve the cold air drainage of fields by removing any barriers, opening fence rows to allow cold air to drain away to lower areas. Some growers even use stationary fans to blow cold air through constrictions in air drain ways.

A GLIMPSE INTO EUROPEAN STRAWBERRY PRODUCTION AND MARKETING

Francesco Di Gioia
Department of Plant Science, Penn State University

The production of strawberry in the European Union constituted by 27 member states was over 1.25 million tons (metric tons) in 2017 (FAOSTAT, 2019), registering an increase of about 21% compared to the production in 2007. Over the same period the strawberry cultivation area slightly decreased (-2.2%) to about 100,835 ha (almost 250.000 acres). Spain is the leader state providing about 28.8% of the European Union strawberry production. Poland has a share of 14.2% and is the state with the largest area invested to strawberry, 49,642 ha (122,668 acres) in 2017. Following, Germany, Italy, and the United Kingdom, provide each about 10% of the EU strawberry production. While most of the states focus primarily on the production of fresh-market strawberries, Poland is leader in the production of processed strawberries, with about 24% of strawberry production for the food industry and 76% reserved for the fresh market. The increase of production observed despite the cultivated area remained quite stable over time may be explained by the evolution of the production method with the partial substitution of cold storage plants with fresh dug plants as well as by the increased adoption of protected culture systems. Within Europe, although each region has peculiar growing systems and varieties, it is possible to distinguish the production of Central Europe and colder mountain areas typically programmed to produce over the summer months, from that of Southern Europe in which different varieties, plant type, and growing systems are used to produce strawberries from December to the end of May or June at the latest. In Southern Europe which provides most of the EU fresh-market strawberries, there has been a clear shift from open field production of cold stored June bearing varieties characterized by a long crop cycle and very short harvesting season with high yield and relatively low quality, to the cultivation in protected environment (mostly multi-bay high tunnels) of short-day or day-neutral varieties, using fresh-dug plants which are normally planted in the fall (October) and if well managed produce high quality berries from the end of January to the end of May-June. This evolution of the growing technique allowed an extension of the availability of strawberries which contributed to assure a year-round production within the EU, with several advantages for the market. Due to the different calendar of production between Southern and Central-Northern Europe there is a lot of movement of strawberries from South to North and vice versa over the year, with Spain, The Netherlands, and Belgium being the main net exporters. Over the last decade there has been also increasing attention to the development of new varieties characterized by high productivity, longer shelf life, and higher quality. At the same time, in the last few years strawberry growers of areas producing fresh market strawberries of recognized premium quality have developed consortiums and marketing programs, like in the case of Candonga Sabrosa produced in Basilicata (Southern Italy) which is leading to a differentiation and better placement of the top quality product on the marked with great return benefits. Like for other production areas around the world, for the long-term sustainability of the strawberry production systems the adoption of good crop rotation systems and best management practices that allow to minimize the use of external inputs are critical. Moreover, there is increasing interest toward more advanced fertilization programs, the production of organic strawberries, and the production of strawberries in media-based soilless systems.

Francesco Di Gioia is Assistant Professor of Vegetable Crop Science in the Department of Plant Science at The Pennsylvania State University. With a 50% research and 50% extension appointment, his integrated research and extension program focuses on developing sustainable vegetable production systems and enhancing vegetable quality. He received his B.S. and M.S. in Agricultural Science and Technology and his Ph.D. in Mediterranean Agronomy working on nutrient management of vegetable crops from the University of Bari in Italy. Before starting his position at Penn State in June 2018, he worked on vegetable crops as a post-doc at the University of Florida from 2015 to 2018 and at the University of Bari from 2012 to 2015.

BEHAVIOR-BASED CONTROL TACTICS FOR SPOTTED WING DROSOPHILA

Cesar Rodriguez-Saona and Pablo Urbaneja-Bernat
Rutgers P.E. Marucci Center for Blueberry & Cranberry Research & Extension,
125A Lake Oswego Road, Chatsworth, New Jersey 08019

Spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura (Fig. 1), is an invasive vinegar fly that can damage many fruit crops including blueberry, cherry, raspberry, blackberry, and strawberry. Native to Southeast Asia, SWD was first detected in the continental USA in 2008. It has since established in many states across the country and was found in the Northeast USA in 2011. Unlike most Drosophila, SWD females are equipped with a large serrated ovipositor, which can saw through the soft skin of many ripening small fruits to lay eggs.

Fig. 1. Female (left) and male (right) SWD. Males have a distinctive black sapot on each wing near the tip. Females are slightly larger than males and possess a large serrated ovipositor.

Current management practices for this pest are driven by chemical control; however, this strategy is not sustainable and its reliance increases environmental, human, and market concerns. To mitigate this, we have been testing behavioral control as an alternative strategy to manage SWD populations in highbush blueberries.

I. Novel Fruit Attractants

To this end, we have: 1) compared the attraction of SWD adults to volatiles from wild and cultivated highbush blueberry fruits; 2) analyze the volatile profiles emitted from wild and cultivated highbush blueberry fruits; 3) identify the antenally-active compounds using gas chromatography-electroantennogram detection (GC-EAD); and, 4) determine the attraction of SWD flies to EAD-active compounds. Fruits from wild and cultivated blueberries, growing in close proximity, were collected from June through August of 2017 and 2018 from three locations in the New Jersey Pinelands National Reserve. In choice (trap and walking) bioassays, SWD flies were more attracted to volatiles from wild than cultivated blueberry fruits (Fig. 2). Wild blueberry fruits emitted higher amounts of volatiles than cultivated blueberry fruits.

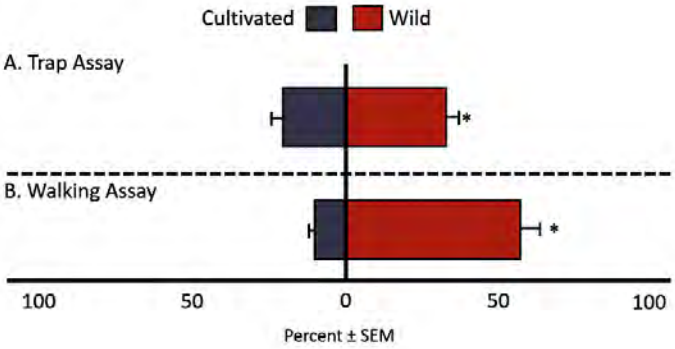


Fig. 2. Percent (± SE) of SWD flies attracted to volatiles from wild blueberries versus volatiles from cultivated blueberries in choice bioassays. An asterisk indicates significant differences (α = 0.05).

Nine EAD-active compounds were identified from wild blueberries; however, there was a stronger preference for four of these volatiles. Although both, the 4- and 9-component blends, were attractive to SWD compared to blank controls, the 4-component blend was more attractive in dual-choice tests. Future studies will determine the attractiveness of this blend to SWD under field conditions.

Cesar Rodriguez-Saona is the Extension Specialist in Blueberry and Cranberry Entomology at the Rutgers P.E. Marucci Center, Chatsworth NJ. He conducts applied research on the development and implementation of cost-effective reduced-risk insect pest management practices and delivers educational information to growers. He received his M.S. degree (1994) in Entomology from Oregon State University and his Ph.D. (1999) in Entomology from the University of California, Riverside. Prior to joining Rutgers University, he worked for the USDA-ARS (Phoenix, AZ), University of Toronto (Ontario, Canada), and Michigan State University (East Lansing, MI). He is native of Lima, Peru. He and his wife Corinne have two sons Renzo and Marcello.

II. Attract-and-Kill Strategies

We have evaluated the feasibility of an attract-and-kill (A&K) SWD SPLAT (Specialized Pheromone & Lure Application Technology; ISCA Technologies, Inc.) formulation to manage SWD under laboratory and field conditions. This formulation is composed of an attractive blend, a small dose of an insecticide, and a phagostimulant. In laboratory studies, SWD SPLAT A&K increased adult SWD mortality. In field trials, SWD SPLAT A&K application to blueberry plots reduced SWD fruit infestation by 2-8 times compared with untreated plots.

In 2019, we tested the effects of SWD density on the efficacy of SWD SPLAT A&K in reducing fruit infestation. Under field cages, we released 0, 20, 40, 60, or 80 females. Treatments included: 1) No SWD SPLAT A&K, 2) SWD SPLAT A&K applied to the foliage, and 3) SWD SPLAT A&K applied to the bark. Regardless of location, SWD SPLAT A&K reduced fruit infestation at densities of 20, 40, and 60 females per cage but not at the highest fly density (80) (Fig. 3). Our results demonstrate the possibility of implementing behavior-based (i.e., attract-and-kill) technologies to manage SWD populations in highbush blueberries, that can be used under conventional and organic farming.

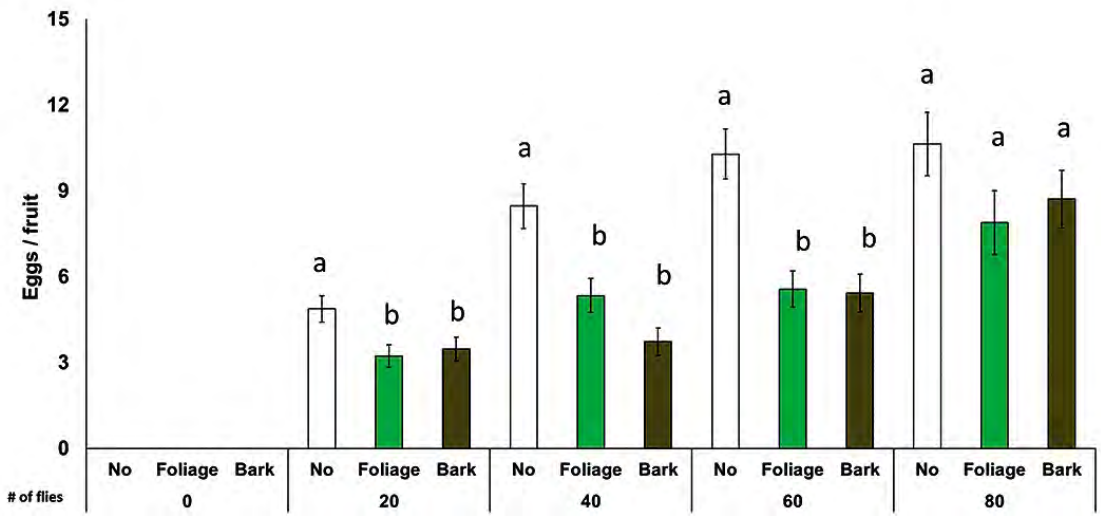


Fig. 3. Number of SWD eggs per fruit (± SE) in cages either treated with 1) no SWD SPLAT A&K, 2) SWD SPLAT A&K applied on foliage, and 3) SWD SPLAT A&K applied on bark at different densities of SWD females (0, 20, 40, 60, and 80). Different letters indicate differences among treatments within each fly density (α = 0.05).

NAVIGATING FOOD SAFETY IN THE PICK YOUR OWN PATCH

Jeffrey Stoltzfus
Penn State Extension

The Food Safety Modernization Act was passed in 2011 as a response to the food borne outbreaks, some of which are caused by workers in the field. FSMA regulations, as well as, most food safety audit standards require growers to train their workers on personal hygiene and other food safety risks. The grower must then have a signed log of workers that have been trained. This obviously becomes unworkable quickly when customers pick their own fruit. Many third party audit schemes require visitor logs of all visitors who enter the field. FSMA does not require visitor logs.

FSMA regulation 112.33 states

"(a) You must make visitors aware of policies and procedures to protect covered produce and food contact surfaces from contamination by people and take all steps reasonably necessary to ensure that visitors comply with such policies and procedures.

(b)You must make toilet and hand washing facilities accessible to visitors."

How do you make visitors of policies and procedures? The same way you make them aware of other procedures, i.e. signs, written instructions, verbal instructions, post them on a website or facebook page.

How do you monitor compliance? You do not have to hire a food safety policeman. However, you are expected to " take all steps reasonably necessary to ensure that visitors comply". If you see something, say something.

What are the policies you need to make visitors aware of:

- Wash ends before picking
- Don't pick when you are contagiously sick
- No pets or emotional support animals in the field (except service dogs)
- Don't pick dropped fruit
- No used cardboard containers
- Fruit contact surfaces should be cleanable with water or single use disposable.

If pickers are required to wash their hands, where can they do that? There are many options for hand washing stations. Some are permanent, some are temporary and portable, some are self contained with clean and waste water. Hand wash stations must have the following:

- Clean, potable water (does not have to be hot)
- Soap, hand sanitizer is not a replacement for soap
- Single use paper towels
- Trash can with lid
- Waste water needs to be captured or drained away from production areas and foot traffic.

What about harvesting fruit for wholesale from PYO fields?

FSMA has no regulations around this practice as long as you are following their visitor policies. However, some auditors and audit standards have not allowed product from PYO fields to harvested for resale after PYO customers have been in them. Check with your auditor to see if this is going to be a problem.

Although food safety regulations may give PYO growers something else to worry about, it ultimately boils down to doing two things;
Make customers aware of your food safety policies and provide toilet and hand washing facilities.

Jeffrey Stoltzfus has been working as the Farm Food Safety educator for Penn State Extension in Lancaster County the past few years. Prior to that he spent 23 years as a farmer educator working for the Eastern Lancaster County School District working primarily with vegetable farmers in Eastern Lancaster County. He has assisted farmers in starting an onion growing cooperative and worked with them in areas of production and food safety. Jeff lives on a small farm where they grow strawberries, pumpkins, and beef cattle.

A REVIEW OF STRAWBERRY PRODUCTION SYSTEMS, BASIC TO ADVANCED

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

Many types of production systems can be used to grow strawberries. June-bearers (also known as short-day plants) and day-neutrals (also known as everbearers) are grown in the Mid-Atlantic region. Both types can be grown in several different production systems. This talk covers matted-row and plasticulture production, the use of low tunnels and high tunnels, and containerized production. We'll briefly discuss vertical production and greenhouse production.

How strawberries grow determines production system practices and the timing of operations. Strawberry plants produce runners when temperatures are warm (above 70 degrees F) and the daylength is long (greater than 10 hours). This means that they produce runners starting in May and continuing into September in open-field production. Environmental requirements for flower bud and branch crown formation vary with type of plant.

June-Bearer Production Systems. June-bearers form their flower buds during short days primarily in the fall, and also in early spring. These plants are typically grown in either a matted-row system where they are harvested for multiple years, or in an annual raised-bed plasticulture system where they are usually harvested for one year.

Matted-row production. In this system, a solid bed of plants is established on bare ground. This system is commonly used for larger-scale production and is popular on pick-your-own farms. Establishment costs are relatively low ($5000-$6000/acre).

Yields are dependent on runner production and daughter plants filling in the row. The planting stock, dormant cold-stored plants, should be planted as early as possible in the spring so that plants have time to establish themselves before the stress of hot summer temperatures. This enables them to produce vigorous runners and daughter plants which in turn, have time to develop. More flowers will be formed in the fall on daughter plants that are larger. The first set of flower buds that emerges from newly-set plants should be removed.

It's important to keep the planting well-watered and weeds controlled, which are particularly problematic in this system. Low rates of Sinbar (1-2 oz per acre) may be used once or twice at weed breakthrough every 30 days or so, and light cultivation is useful as well, especially if the field pass is also used to move runners back into the row. To keep the plants growing vigorously, nitrogen is applied when the first runners emerge, and in late summer. The latter nitrogen application fuels fall growth, and some of it is used in the spring after being stored in the crown and roots. If compost is used instead of inorganic fertilizer, mineralization should supply sufficient nitrogen throughout the summer. The goal is to have 4 to 6 robust plants per linear foot of row; additional runners and daughter plants may be removed when cultivating.

An herbicide (Sinbar) may be applied in early Sept. This use is allowed only during the planting year and is intended to prevent establishment of winter annual weeds. Herbicides are also usually applied before the plants are mulched for the winter. Straw should be applied after the plants are dormant (when leaves are reddish and flatten close to the ground – a plant response to below-freezing temperatures). Watch for weed seed in the straw, especially thistle and dock.

Straw is removed in the spring when the first leaves emerge, barely exposing the plants so the fruit stays clean and weeds are discouraged. Blossoms are protected from frost by using overhead irrigation or row covers.

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

Once harvest is complete, the planting is renovated. This process consists of applying a post-emergent herbicide such as 2,4-D to control broadleaf weeds; then about a week later, the foliage is mowed off, rows are narrowed to 6 to 12 inches wide, and a labeled pre-emergent herbicide is applied to prevent new weed growth. Plants are fertilized with nitrogen at this time and in late summer and are kept watered to spur new growth. Plants are overwintered as in the first year.

Field plasticulture production. Plantings in this system are generally established in late summer or early fall using plug plants, and are most often fruited for only the following spring. This is a relatively expensive system to establish ($6500 to $10,000/acre). Plug plant supply can be limited, so be sure to order plants early (in May) to be assured of having plants when you are ready to plant. Dormant plants may be used just as successfully as plug plants but are planted earlier and runners will need to be removed for a longer time.

The field and plastic-mulched beds may be prepared whenever conditions allow. If plastic mulch is laid several weeks ahead of planting time, some weed seed at the surface may be killed by hot soil temperatures, decreasing weed emergence through the planting holes.

Plug plants are planted from mid-August in cooler areas to mid-September in warmer parts of the region. There is about a 50% yield reduction for every two weeks that planting is delayed after the optimum time. Dormant plants are planted in late June or July. It helps to irrigate the beds thoroughly 2 to 3 days ahead of planting so that the soil in the beds is evenly moist at planting time. No additional fertilizer is needed in the planting year beyond that recommended by the soil test. Runners should be removed about every 2 weeks and before daughter plants start to root in the soil. Row covers should be applied when daytime highs are in 50's to extend growth during the fall and provide winter protection.

In the spring, row covers can either remain over the rows until first bloom in order to advance bloom and harvest time, or they may be removed earlier to delay bloom and harvest, and then be redeployed when frost is a concern.

Fruit anthracnose is extremely common with the cultivars commonly used in plasticulture; fungicide applications to keep the crop protected are often required, or growers must be willing to accept losing a significant portion of the crop to this disease.

Plantings are typically only harvested for one year, as more plants are typically lost during the second winter. If a plasticulture planting is to be kept beyond the first harvest year, some growers remove the plastic mulch and convert the planting to a raised bed matted-row system.

High tunnels or low tunnels. High tunnels or low tunnels can be used when growing June-bearing varieties, though economic viability is a concern. Tunnels have the most value in organic systems, as they greatly decrease the incidence of fruit rots and improve shelf-life without fungicide use.

Day-Neutral Production Systems. Day-neutral varieties produce flower buds regardless of daylength, and thus they fruit continuously during the growing season. They may be used in a variety of production systems.

Field plasticulture production. Day-neutral varieties are nearly always grown in plasticulture rather than matted-row production, with higher yields obtained on white mulch rather than black. The planting process is similar to that used for June-bearers, except that dormant plants are used rather than plug plants, and planting takes place as early in the spring as possible. The first set of blossoms is removed, as are runners as necessary. Plantings are fertilized according to soil test results before planting, and then through the irrigation system weekly at about 1-2 pounds of nitrogen per acre per week, depending on variety. Harvest begins in late June or early July and continues through the fall when the heaviest yields are produced. Row covers may be applied to protect the crop from fall frosts, and then can be used to overwinter the plants. If plants are overwintered, usually only the spring crop is harvested, as fruit size often decreases thereafter.

Low tunnels. Most day-neutral varieties are quite susceptible to fruit anthracnose. For this reason, low tunnels can result in a much higher percentage of marketable fruit especially when fungicides are not used as in organic systems.

Low tunnels are generally used in combination with a plasticulture system in the field. They are quite labor-intensive to set up and manage. Keys to success include using a system that keeps the plastic well-anchored, having ties over the top of the tunnels that put tension on the plastic, and using a thin plastic made specifically for low tunnels (1.5-mil) than can be pulled tight to avoid water ponding on the plastic.

High tunnels. Much of the world's strawberry production takes place under large-scale multi-bay high tunnels. In this region, day-neutrals are the type of plant more commonly grown in tunnels. Other crops provide a higher return per square foot, and thus may be a better use of tunnel space if it is limited. However, the percentage of strawberry production in high tunnels is expected to increase as tunnels provide increased control over the environment, a longer harvest season, higher marketable yields (25% increase to double the yields), and a longer shelf-life. Pay-off varies and time is required for tunnel management, though harvest can take place regardless of weather conditions. Any production system that can be used in the field can be used in a tunnel, with the plasticulture system being most commonly used.

Containerized and soilless production systems. Containerized systems are most commonly used in a high tunnel or greenhouse, and yield per plant can be high, often over 2 pounds per plant. Success is more likely when: 1) using a media with good drainage and water-holding capacity to make watering interval less critical (a 2:1 peat:coarse perlite mix works well), 2) using deep enough pots so there is more buffering against over-watering or under-watering (1-gallon grow-bags or pots provide this), 3) using a good-flavored firm cultivar that doesn't soften with overwatering or high temperatures ('Albion'), 4) providing consistency in watering as with a dripper-stake system, 5) planting as early as possible so growth is maximized, and 6) using a constant-feed fertigation to provide sufficient nutrients. A 100-ppm N complete solution using a fertilizer type that is appropriate for the local water hardness generally works quite well.

Vertical systems. Vertical systems perform better at lower latitudes with a high sun angle. In northern regions, either stacks need to be quite short, or rows need to be spaced quite far apart to avoid excessive shading of the lower plants. Shaded plants grow less, which means they need less water, which means plants lower in the stack are often overwatered. This variation in moisture can be overcome by using a very porous media such as perlite, but then the low water-holding capacity causes additional challenges in providing sufficient moisture.

Greenhouse production. The containerized system discussed above works as well in greenhouses as it does in high tunnels. A question remains though as to the profitability of greenhouse production with this system. Hydroponic strawberry acreage, though small, is increasing, and is usually undertaken by growers with considerable experience in hydroponic production of other crops.

HOW BLUEBERRIES GROW: WHAT'S NORMAL, WHAT'S NOT

Mark Longstroth
Michigan State University Extension, Extension Small Fruit Educator

Blueberries are an unusual plant in several ways. They require acid soils to thrive. Not 6 but 5. If the soil pH is not 6 or below, I tell people to find another site or grow something else. Stunted yellow plants are never productive. If you must grow blueberries in a poor site, you would be better off bringing in soil or acidifying the irrigation water to get the soil pH below 5.

Blueberries have a small root system and the white roots lack root hairs which means the plant has problems absorbing water and nutrients from the soil. On hot days when the plant is fully leafed out and carrying a load to fruit the plant needs about 4 gallons of water every day. Irrigation is needed to maintain good shoot growth and size young fruit in the spring, ripen the fruit in the summer and set flower buds and store reserves for next year in the fall.

The permanent perennial part of the blueberry bush is the crown which sends up new shoots every year. The shoots bear fruit at the ends of last years growth and branch below. As the stems age they become less and less fruitful and should be removed as they age making room for new shoots to take their place. One of the most common problems I see is growers afraid to remove older shoots to stimulate new growth. Typically, they are afraid to remove fruit buds but the fruit on older wood is usually small. Too small to pick by hand, which is why machine harvesting for the process market is so common.

The blueberry bush has two types of buds, flower buds and vegetative buds. The flower buds have only flowers in them and bear fruit, while the vegetative buds only form leaves and shoots. Flower buds are big, plump and easy to see and are located at and near the shoot tips. The vegetative buds are small and pointed and are located further down the shoot. The blueberry bush only has buds on last year's growth.

In the early spring, bud growth of the buds is visible as swelling of the buds. The buds at the shoot tips begin growth first, then the buds below follow in turn. The bud growth begins in a wave that moves down the stem. The different growth stages have names describe them. Flower buds swell and then burst revealing the flower cluster inside. Leaf buds swell, then the new leaves emerge from the buds (green tip), before the bud bursts and the leaves begin to unfold.

The flower buds in blueberries contain a cluster of flowers. There are 5 to 12 flowers in a cluster. The flower buds emerge as a tightly packed cluster (tight cluster). As the flowers develop the corolla (the petal tube) is visible as pink tissue at the tip of the flowers (pink bud). As the flowers develop the petal tube expands and the pink fades to white. Bloom begins when the tip of the corolla opens (first bloom). The flower clusters at the shoot tip begin bloom first, with bloom progressing down the shoot. The flower cluster is a raceme, meaning the flowers at the base of the cluster were the first formed and the oldest. The flowers at the base of each cluster open first. The first flowers pollenated have the potential to be the largest fruit. Fruit from the later blooms is smaller. The early period of fruit growth is very important in determining final fruit size. For several weeks the fruit grows quickly by cell division. Cell division in the fruit then stops. Then the fruit grows by cell enlargement. Bigger fruits have more cells because they grew earlier and faster in the spring. Final size of the fruit is determined soon after bloom.

In the early spring we have both shoot growth and bloom and fruit growth. Since the fruits and shoots are rapidly growing at the same time, they are competing for the available resources and water in the plant. Initial growth is supplied by carbohydrates stored in the bark and wood of the shoots. As the shoots form new leaves these leaves feed both the developing fruit and new growth in the shoot. As long as we maintain good soil moisture during the growing season, the roots can maintain an adequate flow of water to the leaves to maintain growth. As the plant becomes fully leafed out, it becomes harder and harder to maintain the volume of water needed to maintain growth and photosynthesis. A hot day can cause the tips of the new shoots to wilt from lack of water. This wilting signals the end of shoot growth. Soon the apical bud at the shoot tip dies stopping shoot growth. By the time the fruit starts its final swell for harvest, most of the shoot and leaf growth for the season has stopped. Fruit growth takes all the plants energy. When blueberry shoot stops the tip of the shoot dies. You can actually

Mark Longstroth is a Small Fruit Extension Educator for Michigan State University Extension. He has worked in the fruit industry since 1978. He began working for MSU Extension in 1994 and has over 25 years' of Extension experience working in the Michigan fruit industry. Prior to 2010, he covered all tree fruit, grape and berry crops in Southwest Michigan. Mark now focuses on blueberries, grapes and other berry crops. His main education efforts are in crop production, pest management and farm financial management. He has developed cost of production budgets for blueberries and other fruit crops. Mark is especially interested in the impacts of weather and climate on fruit production. Mark's wants to help growers remain profitable and adapt to changes in agriculture.

see the small withered leaf of the dead shoot tip. Soon you will notice there are no new small leaves at the shoot tips, but all the leaves on the shoot are fully formed. I want to see 8 to 12 inches of good shoot growth from many of the shoots on a bush.

In August, the shoot begins to form new flower buds. The uppermost bud on the shoot becomes a fruit bud. If the plant is not stressed and has had good growth more of the buds below the tip will develop into flower buds. After harvest, the plant prepares for next year's growth by storing reserves for next year's flush of spring growth. Under good growing conditions another flush of shoot growth may begin. Late shoot growth is susceptible to winter injury and normally will not set fruit buds.

In the fall, flower buds are formed for next year's crop. The terminal shoot bud becomes fat and plump as it changes from a leaf bud to a flower bud. Under good conditions other leaf buds below the terminal bud will also change to fruit buds.

The growth pattern of blueberries is to form flower buds at the ends of the shoot and to branch below. As the shoot grows and matures it develops more and more branches. These branches get smaller and smaller with few and few flower buds on the shoot. Older stems have lots of short branches with a single flower bud at the end of a short shoot only an inch or two long. While there are lots of flower buds on these older branches the weak shoots have small leaves and only grow small fruit. These older shoots need to be pruned out to force the plants energy into producing young vigorous shoot with lots of flower and shoot buds on the young shoot that produce large fruit rather than the small fruit of older shoots.

BASICS FOR ESTABLISHING A SUCCESSFUL BLUEBERRY PLANTING

Mark Longstroth
Michigan State University Extension, Extension Small Fruit Educator

Establishing a perennial fruit planting is an expensive endeavor. It will take 6 to 8 years before a planting is producing enough fruit to be a viable commercial enterprise. Because of the long establishment period many people will try to cut corners and reduce costs. This seldom works and money saved at the beginning is usually many times less than the profits lost as the planting may take 12 or more years to be profitable and is never as profitable as one which was developing a focused attempt to produce the best possible blueberry field. The initial costs for the first 6 years of a blueberry planting are 15 to 25 thousand dollars per acre. Depending on the variety you should be able to get 5 to 8 thousand pounds acre, if they are irrigated. The growing costs are about 2 to 3 thousand a year. Growing organic is a possibly but yields will be lower and controlling the spotted winged drosophila (SWD) will be a problem.

The first step is to find out if you can easily grow them if not, they can be an expensive money pit.

Blueberries prefer acid soils with a pH of 4.5 to 5.5. Many people want to quickly adjust their soil pH. There is no quick easy way to change soil pH. The cheapest way to lower the soil pH is to add elemental sulfur to the soil. If the soil pH is greater than 5.5, apply elemental sulfur to decrease the soil pH to 4.5. Spring application and incorporation work best. Soil bacteria convert the sulfur to sulfuric acid lowering the soil pH. This is a biological process (slow) and not a chemical reaction (rapid). The bacteria are active, when the soil is moist and warm. The soil temperature should be above 55F. Since the bacteria are not active in the winter, fall applications of sulfur have little effect on the soil pH next spring. The soil must not be flooded (anaerobic) or the sulfur is converted to hydrogen sulfide which kills plant roots. Irrigate to maintain soil moisture but do not over irrigate the soil. The amount of sulfur required is dependent on soil texture. Clay and organic matter act as a buffer, absorbing and releasing mineral ions. Relatively little sulfur is needed on sands, whereas soils high in clay or organic matter require much more. It is important to apply and incorporate sulfur at least a year before planting. This allows the sulfur time to react and lower the soil pH before planting. If large changes in pH are needed, it may be better to bring in soil to create the proper soil conditions.

Growers routinely incorporate organic matter into the soils as well to increase the organic matter in the soil. I generally don't care what type of organic matter it is, but I am concerned about the pH of the material. Composts and manures are generally alkaline so avoid them. Check the pH of any soil amendments you add. Many growers use sawdust, wood chips or the waste from clearing trees and brush. I don't want any black walnut in this scrap. Some perennial weeds may be brought in as seeds, stems or roots. You should make a concerted attempt to remove any perennial weeds from the planting now before planting blueberries restricts your herbicide choices and timing.

Blueberries have a small root system so an irrigation system is a must. Blueberries prefer moist, not wet soils. If they dry out during the growing season, growth stops. On hot days when the plant is fully leafed out and carrying a load to fruit a mature plant can use 3 to 4 gallons of water. Irrigation is not just important it is mandatory to maintain good shoot growth in the spring, ripen and size the fruit in the summer. You need a healthy plant to set flower buds and store reserves for next year in the fall. Different irrigation systems each have their advantages and disadvantages. The important thing is to be able to provide enough water to the plant on a continuous basis to avoid drought stress.

In Michigan, most blueberries are planted in the fall. Our sites are too wet for early planting in the spring. We usually plant potted plants with the leaves still on them. Planting usually happens in September. This allows the plant to get well established in the fall, getting off to a good start in the spring.

Don't be in a hurry at planting time. Be sure to break up the root ball of the potted plant when you plant it. When you pop it out of the pot, pull the root ball apart. Pull the bottom of the root ball apart so the root system is twice as wide and half as deep as it was in the pot. Spread the root system out in the hole. Almost all the roots are around the outside of the pot where the aeration in the pot was best. This is where the new roots will come from. If there is a real difference in soil texture between the

Mark Longstroth is a Small Fruit Extension Educator for Michigan State University Extension. He has worked in the fruit industry since 1978. He began working for MSU Extension in 1994 and has over 25 years' of Extension experience working in the Michigan fruit industry. Prior to 2010, he covered all tree fruit, grape and berry crops in Southwest Michigan. Mark now focuses on blueberries, grapes and other berry crops. His main education efforts are in crop production, pest management and farm financial management. He has developed cost of production budgets for blueberries and other fruit crops. Mark is especially interested in the impacts of weather and climate on fruit production. Mark's wants to help growers remain profitable and adapt to changes in agriculture

potting medium and the native soil, mix some peat with the native soil in the planting hole. Compost or composted manures should not be added to the planting hole. These materials will raise the soil pH.

More and more Michigan growers are using mulches to maintain the soil moisture around the plants. They are using wood chips or woven plastic weed fabric. Do not use solid plastic sheeting! This mulch moderates soil moisture and temperature. In a fall planting I do not recommend any pruning at planting time. Nor do I recommend any fertilizer, but the irrigation system should be up to provide supplement irrigation under dry conditions.

The following spring, I recommend doing a lot of pruning. Remove all the weak spindly shots and older shoots that do not look vigorous. Do not be afraid to remove the largest shoot or the only shoot if there is only one shoot. The goal is to develop a bush which sprouts new shoots from the base of the plant each year. If you do little pruning, growth is poor. The plants from the nursery have been pampered and well fertilized and should begin growth quickly. If not, force the plant to send up new shoots. I have growers who remove all the old shoots the second year leaving only the shoots that grew the year before. Your goal is to grow a bush, a large bush as quickly as possible and get into production.

In the second and third years you should remove all the flowers early in the spring before bloom. The flowers are located at the shoot tip and can be easily rubbed of or cut off. Remember your goal is to establish the bush as quickly as possible. Also remove any dead or diseased shoot tips. I recommend removing the flowers for 3 or 4 years as the fruit just stunts shoot growth.

Blueberries utilize only the ammonium form of nitrogen. They do not utilize the nitrate nitrogen found in many fertilizers. For fertilizer, we usually recommend using urea (46-0-0) if the soil pH is below 5 and ammonium sulfate (AMS, 20-0-0) if the soil pH is above 5. MSU recommends about 16 to 20 lb. of actual nitrogen for new plantings. That is about an ounce per plant with a planting distance is 3 by 10 feet (1456 plants/acre) For phosphorous, I recommend one of the ammonium phosphates as these are more soluble and readily available in acid soils. Blueberries don't like chlorine or calcium, so I avoid those in fertilizer blends. Potassium Magnesium Sulfate is good to use to get the potash and magnesium.

A REVIEW OF RASPBERRY AND BLACKBERRY INSECTS AND MITES

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

Many insect and mite pests sporadically damage raspberry and blackberry production, and pest pressure varies by region, crop, and harvest timing. The economic impact of insect and mite damage also differs by market and production strategy. Regular, careful scouting and accurate pest identification are key for effective management. Early detection of potential issues provides more management options. Effective management tactics vary by pest. Weekly scouting from bud break until the fall and at least one dormant inspection is recommended. Cultural practices such as removing wild brambles from the planting area and crop rotation are also important for bramble insect pest management. For example, wild brambles can harbor raspberry and red-necked caneborers. Because brambles are rarely the only crop grown on a farm, pest issues can arise from other crops. For example, sap beetles will migrate from post-harvest strawberries into bramble plantings. I will briefly discuss seasonal scouting and management for some common pests of brambles. Further details on insect and mite pest management in brambles can be found on Extension websites.

Dormant (late Fall to early Spring) Pests: Cane and crown damage is most visible during dormancy when leaves have fallen. Scout for damage from cane and crown borers, looking for swellings on the cane. It is important to identify the boring pests because their life cycles vary considerably. Crown borers typically cause swellings near the base of the plant and the larvae within the swelling will have short dark legs near the head. Remove and destroy plants infested with crown borers. Rednecked caneborers cause very similar swellings that are usually higher up on the plant (often about a foot from the ground), and their larvae do not have legs. Remove and destroy canes with swellings from late fall to early spring. Tree cricket eggs are laid by puncturing the outer bark and leave a row of circular punctures. These occasionally kill the cane above the injury and can also be pruned out (cut off below the damage) at this time. Holes and hollows in spent canes are caused by solitary bees which use the dry woody material as nests and are not of concern. Scale insects are not a common problem in our area, but are best managed during dormancy, so keep an eye out for them when scouting dormant plantings.

Pre-Bloom Pests: Inspect tender cane growth and leaves for aphids, leafhoppers, blackberry psyllids, spider mites, and broad mites. Their damage often causes discoloration and distortion of the leaves, such as cupping and curling. These pests are all very small, reproduce quickly, and their management varies, so it is important to locate and identify them. Similar damage may be caused by viruses, which can be vectored by aphids, or from herbicide damage. Often the mite/insect can be found within the curls on damaged leaves or on nearby leaves and shoots. Scout for raspberry cane borer damage including wilting cane tips and two rings of punctures near cane tips. Cut off the tip back to where the center of the cane is no longer hollow and destroy before midsummer. Flower buds should be inspected for discoloration (may be caused by thrips), bud feeding (piercing or chewing wounds), and bud clipping. Look for adult strawberry clipper beetles, adult (active during early evening) and larval raspberry fruitworm beetles, tarnished plant bugs, and Japanese beetles.

Bloom Pests: Insecticides should not be used during bloom to avoid toxicity to bees. Bee-safe products can be used if absolutely necessary and should be applied when bees are not active, during cool, early mornings or in the evening.

Kelly Hamby is an Assistant Professor and Extension Specialist in the Department of Entomology at the University of Maryland. Her research and extension program addresses invasive and emerging insect pest issues, evaluating and optimizing pest management programs, and development of sustainable alternative management tactics in small fruit and grain systems. She received her B.S. in Environmental Toxicology, M.S. in Entomology, and Ph.D. in Entomology at the University of California Davis. Originally from California's Central Valley, she and her husband Scott McCluen enjoy bird and insect watching.

Petal Fall Through Harvest Pests: Continue scouting foliage and canes, especially new growth, for aphids, leafhoppers, blackberry psyllids, spider mites, broad mites, raspberry cane borers, and Japanese beetles (See Pre-Bloom Pests). Inspect fruit for chewing and piercing sucking (needle like) damage. Open soft and feeding-damaged fruit to look for larvae. Spotted wing drosophila have small white legless larvae with no apparent head, and damaged fruit often feel soft and leak juice. Sap beetle larvae are also very small and pale in color, but have an apparent head and 3 pairs of legs, which requires a hand lens to see. Raspberry fruitworm larvae are slightly larger and more amber colored than sap beetle larvae but otherwise are very similar. Inspect fruit clusters for adult insects, such as green June beetles, Japanese beetles, wasps, stinkbugs and other true bugs that may be found feeding on the fruit.

Post-Harvest Pests (late Summer to Fall): Scout for significant foliar damage by Japanese beetles and spider mites. Spider mites are particularly of concern in new plantings. If crown borers have been problematic, consider management for crown borers.

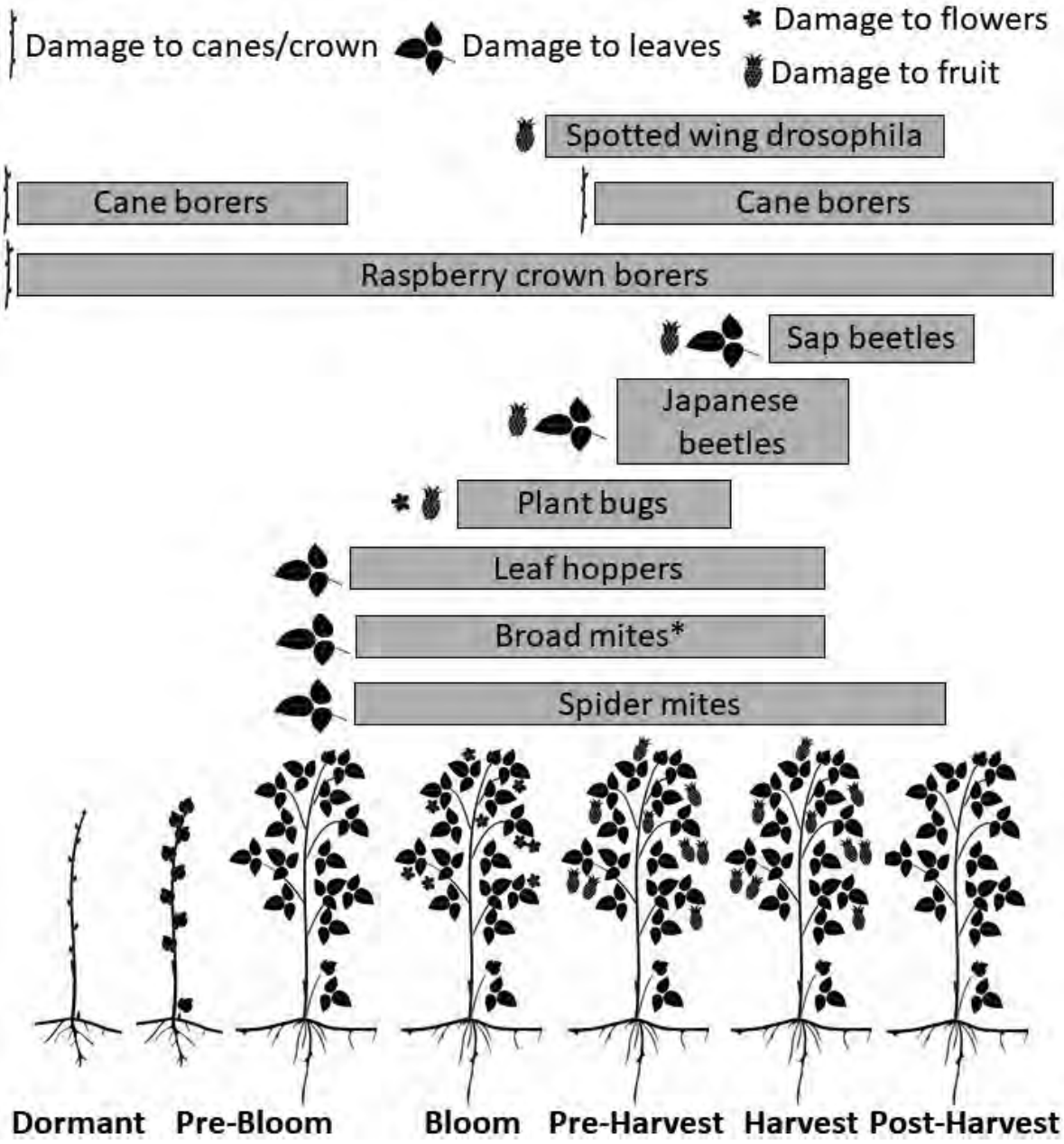


Figure 1. Common bramble pests, the plant part they damage, and rough estimates of their damage/activity window (grey bars).

*Broad mites are primarily of concern in primocane blackberries.

PHYLLOLUX - A NEW UV-C LIGHT BASED TECHNOLOGY FOR CONTROL OF STRAWBERRY DISEASES, INSECTS AND MITES

Wojciech Janisiewicz, Fumiomi Takeda and Tracy Leskey
US Department of Agriculture, Agriculture Research Service, Appalachian Fruit Research Station,
2217 Wiltshire Road, Kearneysville, West Virginia 25430 USA

Limitations of pesticides and increasing consumer demands for fruit free of pesticide residue necessitate the search for alternative disease and pest control strategies. This is particularly clear with strawberry culture where the lifespan of pesticides before resistance develops is not long and often forces growers to rotate among several pesticides, increase the frequency of application before the chemical is eventually rendered obsolete or use new pesticides with different chemistries. Integrated Pest Management (IPM) is an important approach to extend their lifespan but it is still not totally effective. Thus, sustainable alternative approaches not relying on the application of synthetic chemicals are urgently sought.

In 2011 a project was initiated at the Appalachian Fruit Research Station to explore the use of germicidal ultraviolet (UV) irradiation for the control of major diseases of strawberries, which quickly expanded to control of mites and insects as well. Prior research on using UV irradiation to control diseases on various crops, conducted for more than two decades in various laboratories world-wide, was hampered by a high level of damage to plants by irradiation doses required to kill the microbes causing plant diseases. In our approach, we focused on new ways of using UV-C light and explored a mechanism by which it kills microbes so that UV-C could be used to kill microorganisms but not damage the strawberry plant. A dark period of 2-4 hours immediately after the UV-C treatment prevented microbes from repairing DNA damage (repair mechanism requires daylight) caused by UV-C irradiation. This method of UV-C light treatment resulted in lowering the doses required to kill the microbes by six to ten fold. Fungi causing gray mold (Botrytis cinerea), powdery mildew (Podosphaera aphanis) and anthracnose (Colletotrichum spp.) of strawberries were killed at much lower UV-C doses in in vitro plate assays as well as on plants. Irradiation of strawberry plants for 60 seconds at midnight twice a week were adequate to control these diseases. The reduced doses required to kill the plant pathogens caused no apparent damage to strawberry plants. More specific tests showed: a) no damage to chlorophyll, b) no reduction in photosynthetic activity, c) no reduction in pollen viability and germination, tube length and growth through the style, and d) no effect on fruit set or deformation of the fruit that would indicate fertilization was not adequate. Chemical analysis of phenolic compounds in treated strawberry fruit showed no abnormalities, and compounds particularly well known for the health benefits such as ellagic acid, quercetin and kaempferol were at the same level in UV-C treated and untreated fruit.

To fill the microbial void after "sterilization" with UV-C irradiation, two beneficial yeasts were applied to strawberry plants. These yeasts were originally isolated from apples harvested from trees growing at the Appalachian Fruit Research Station. They were shown to be excellent colonizers of strawberry flowers and leaves as well as controlling gray mold. The two yeasts were effective in colonizing plant surfaces to prevent recolonization by undesirable microbes and provided an additional level of diseases protection.

Dr. Wojciech J. Janisiewicz, Research Plant Pathologist at the USDA-ARS Appalachian Fruit Research Station in Kearneysville, WV received his M.S in 1979 and Ph.D in 1983 from Washington State University and has been working at the present location for the past 35 years. During this time Dr. Janisiewicz's research has been focused on studying naturally occurring bacteria and yeasts on pome and stone fruits and its potential for biocontrol of postharvest diseases of fruits as well as foodborne pathogens. He developed the first bacterial commercial product, BioSave®, for controlling postharvest diseases of fruits and vegetables. Together with his close collaborators Dr. William Conway and Post-Doctoral Associate Britta Leverentz, he demonstrated that the application of BioSave® and other bacterial and yeast biocontrol agents developed for control of postharvest decays can reduce the risk of contamination of fruit with bacterial foodborne human pathogens. These research and later work with bacteriophages affecting foodborne pathogens on fresh cut fruit have been an inspiration to many programs world-wide and resulted in developing product SalmoFresh by Intralytix Inc. to control Salmonella spp. on fresh produce. His current research focuses on a novel use of UV-C irradiation in combination with yeast biocontrol agents which is the foundation of the PhulloLux technology that is currently under commercial development.

Early on we observed that UV-C irradiated strawberry plants had markedly lower level of mite infestation in comparison to non-irradiated control plants. A detailed study with plants artificially infested with two-spotted spider mites revealed that nightly 60 second UV-C irradiation of plants reduced mite populations to below a commercial treatment threshold of 5 mites per mid-canopy leaflet. Tests on strawberry plants artificially infested with greenhouse whitefly showed a decline in adult populations on UV-C treated plants while on untreated plants they increased many fold during the six week period. During the same time period nymph counts declined to an almost undetectable level on treated plants. In another study, fruiting strawberry plants were artificially infested with female spotted wing drosophila and then subjected to the UV-C treatment. The ripe fruit was harvested and incubated in cups to determine the percentage as well as mean number of infested fruits. Both declined many-fold in comparison to untreated controls.

An autonomous UV-C irradiation apparatus for high tunnel production of strawberries and a prototype with bidirectional UV-C irradiation sources for table top production of strawberries were developed. Both were successfully used in high tunnel and greenhouse experiments, respectively. In collaboration with TRIC Robotics, a robot prototype was developed for field application of the PhylloLux technology, that now includes nighttime UV-C irradiation followed by immediate application of yeast antagonists.

ENHANCING FALL 'ALBION' STRAWBERRY PRODUCTION WITH INEXPENSIVE FIELD LIGHTING: DOES IT REALLY WORK?

Edward F. Durner
Department of Plant Biology • Rutgers, The State University of New Jersey
59 Dudley Road, New Brunswick, NJ 08901, USA
durner@sebs.rutgers.edu; Tel: 848.932.6366.

Fall Strawberries

In the late 1990's I developed a greenhouse based, off-season strawberry production system using photoperiod and temperature conditioned plants of the short-day cultivar 'Sweet Charlie'. Plugs were given short days followed by chilling in a walk-in cooler, then planted in a hydroponic greenhouse system for mid-winter production. The system was never commercially adopted due to the cost constraints associated with the conditioning protocol.

A much more feasible approach uses the long-day cultivar 'Albion', planted in the spring or early summer for fall production the same season. Numerous reports in the literature describe efforts to develop off-season strawberry production systems for temperate North America using long day cultivars in field or protected culture. Conditioning of plant material before planting may or may not improve off-season fruiting, depending on planting date.

The current recommendation for off-season LD cultivar production is to use dormant, cold-stored crowns planted directly in the field as early in the spring as possible (before May 1). Field conditions (wet and cold) often preclude early planting dates in the eastern US. In these situations, plugs can be produced in the greenhouse from dormant, cold-stored crowns then planted in the field when conditions allow however, later planting leads to a reduction in yield.

Photoperiod and nitrogen conditioning may enhance flowering and off-season, fall field production in long-day cultivars depending on field planting date and plug size. Elevated nitrogen during floral initiation enhances and accelerates flowering of long day cultivars. The response to conditioning is rapid (4 weeks after treatment) and cultivars respond with increased rate (enhanced precocity) and intensity (enhanced inflorescence/flower number) of flowering with elevated N. The reduced yield often observed with later planting (22 July) is alleviated with photoperiod and nitrogen conditioning, however, earlier plantings (2 and 22 June) do not benefit from conditioning. While larger plugs are often more productive than smaller ones, fewer larger plugs are produced per unit area, thus smaller plugs are often utilized. Smaller plugs of LD cultivars are often less precocious and productive due to a SD response imposed by higher plant density during propagation. When smaller plugs are used, their precocity and early fall production is enhanced with conditioning.

This past season, supplemental field lighting with inexpensive holiday light strings was evaluated as an alternative to greenhouse conditioning. This approach eliminates greenhouse 'plug' (acutually potted dormant crowns) production with concomitant conditioning with photoperiod and nitrogen.

Plants were lit with supplemental lighting daily, for 15 minutes every hour from 7 pm to 7 am for 28 days in July or 28 days in August. Flowering and fruiting were evaluated to determine if either or both treatments enhanced long-day flowering in 'Albion'. Flowering and fruiting were both enhanced with the supplemental lighting.

If you are interested in trying such an approach, e-mail me at durner@sebs.rutgers.edu and I can provide you with more details on how to do it.

This work is supported by a New Jersey Department of Agriculture / USDA Specialty Crop

Dr. Edward F. Durner is an Associate Research Professor in the Department of Plant Biology at Rutgers University. He grew up in Annapolis, MD and attended The University of Maryland for his BS, Virginia Tech for his MS and North Carolina State University for his PhD. He has been at Rutgers for 35 years. His research, teaching and outreach activities involve flowering physiology of strawberry and developing goldenberries as a new crop for North America. He was the Director of The Student Sustainable Farm at Rutgers CSA from 2006 through 2015 where he managed a 5-acre CSA in addition to his teaching and research responsibilities, thus he has first-hand experience with understanding the challenges growers face these days.

A REVIEW OF BRAMBLE DISEASES AND THEIR MANAGEMENT

Kathy Demchak
Penn State University, 102 Tyson Bldg., University Park, PA 16802
efz@psu.edu

Raspberries and blackberries are susceptible to a number of diseases that affect their fruit, canes, leaves and root system. Most of the bramble diseases that are common in the region, and how to manage them.

Diseases Affecting the Fruit

Diseases affecting fruit are among the most noticeable of issues, because they noticeably decrease how much fruit is marketable. Fortunately, here are relatively few in the region that cause a significant portion of fruit to be lost.

Botrytis fruit rot, or gray mold. This disease primarily infects fruit during bloom when spores land on the stigma and grow through the style like pollen grains do. Within the planting, botrytis overwinters on the canes, but it is also likely to be present on old or decaying vegetation. Botrytis is more problematic during spells of cool temperatures and damp conditions. Symptoms are a characteristic gray fuzz, and if the fungus is magnified, one can see clumps of small white spores (conidia) at the tips of dark grey stalks. Botrytis can kill flower buds and cause lesions on the canes, though this is not as problematic as fruit infections. Cultural management measures include any practice that encourages drying of the plants. Pruning thoroughly, keeping weeds under control, trellising so fruit is held off of the ground, and thorough harvest are all helpful measures. Fungicide applications during bloom and through harvest are recommended.

Cladosporium fruit rot. Fruit loss to this disease except as a storage rot had been almost unheard of in years past, but reports of issues during raspberry harvest in high tunnels have become more common. In these cases, Cladosporium caused the presence of tiny spots of very dark olive-green mold to appear on the fruit. According to work done at the Univ. of Maryland (by C. Swett and K. Hamby), spotted wing drosophila infestation was implicated in an increased incidence of this disease, so measures to control spotted wing drosophila maybe helpful, as should cultural controls to decrease humidity and improve air flow within the tunnel.

Late leaf rust. Late leaf rust affects mainly red raspberries, and is most problematic late in the season, as the name implies. Both leaves and fruit are affected, but since fruit of summer-bearers generally ripens before infection becomes widespread, rust on the fruit is more likely to be seen on primocane-fruiters. In the mid-Atlantic, leaves of the summer-bearing black raspberry 'Jewel' and both leaves and fruit of the primocane-fruiter 'Niwot' have been affected. The appearance of the rust on the fruit makes it unmarketable. Late leaf rust is not a systemic disease, unlike orange rust (discussed below). In severe cases, late leaf rust can cause premature defoliation in the fall and may affect a large proportion of fruit on susceptible cultivars, especially 'Heritage'. White spruce and Engelmann spruce are alternate hosts but appear not be required for the disease to persist. With primocane-fruiters in tunnels, cutting down and removing floricanes so that only a fall crop is produced for a year and removing dead leaves to remove inoculum appears to break the disease cycle. Because this is not a systemic disease, fungicides in groups 3 and 11 are effective, but both are at risk for resistance development. Including fixed copper in rotations is recommended as a way to decrease the risk of resistance development.

Post-harvest rots. A number of post-harvest diseases that cause fruit to soften and leak are common. Cultural measures that improve air flow in the planting, and rapidly cooling of fruit and storing it at temperatures near 32 degrees F will greatly decrease their incidence.

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

Foliar diseases

Orange rust. One very widespread and incurable disease is orange rust. This disease affects black raspberries and blackberries and can cause a planting to become unproductive. Usually the first symptoms noticed are bright orange pustules on leaf undersides in late spring. However, the canes emerging from an infected plant earlier in the spring are smaller and weaker than normal and have a light color. This fungus has a complex life cycle which complicates fungicide application timing. In addition to the obvious orange spores that are produced early in the season, a much less evident type of spore is produced later in the season.

The only cure is to dig out infected plants. To minimize spore dispersal, carefully prune out and bag infected canes in sections, or bag the entire plant if you can and then cut the canes at the base. Then proceed with digging out the root system. Mark the location and check the following spring for emerging canes that may be sprouting from residual root pieces. If it appears that infected canes are emerging, dig and remove those before the orange pustules are formed. Fungicides in chemical classes 3 and 11 help protect uninfected plants but cannot cure plants once they are infected.

Leaf spots. There are fungal leaf spots that affect raspberries and blackberries but the species that affect each are different. As with other diseases, improving air flow through the planting and employing any practice that encourages drying of foliage is helpful.

Cane and crown diseases

Crown gall and cane gall. These diseases are caused by one of two species of bacteria than cause the plant to form tumors usually in areas where the plant had been wounded, such as where pruning cuts were made. This is why symptoms usually show up in the crown area – however, they may be on roots below ground as well. Planting clean stock into clean fields is critical. As with orange rust, the only cure is to dig out infected plants, making sure to remove as much of plant and its root system as possible. Keep an eye on future growth in the area for presence of additional galls on remaining plant material.

Spur blight causes chocolate brown lesions on primarily, but not only, red raspberry canes in the vicinity of a node, and usually only in the lower portions of the cane. This infection started in a leaf that had been attached at the node, and then progressed through the leaf into the cane. Infected leaves are often shed prematurely, so may no longer be present by the time cane symptoms develop. Buds at infected nodes may fail to break in the spring, or they may grow normally. Avoidance of excessive growth and weeds that cause foliage to remain wet is helpful. Lime sulfur in spring can help to decrease the incidence of disease.

Cane blight can cause buds to fail to break, and cane death. The fungus typically only infects plants when canes have been wounded through activities such as cane tipping of black raspberry or from abrasion. For this reason, waiting to tip canes until a dry spell is expected is recommended as is applying a fungicide after tipping if waiting for a dry period isn't feasible and rain is expected.

Botryosphaeria stem canker. This disease affects primarily thornless blackberries and can cause heavy yield losses. Reddish-brown lesions develop on the cane and may girdle it, causing cane collapse at the time of fruiting. Cultural methods to reduce incidence include avoiding planting blackberries near other susceptible crops such as apple and blueberry and avoiding excessive nitrogen fertilizer applications.

Gnomonia cane canker. This disease is a bit of an enigma, as the disease appears to affect floricanes primarily, which is an indication that winter injury may be the real trigger for appearance of this disease.

Root rots

Phytophthora root rot. A number of different Phytophthora species have been isolated from plants suffering from this disease. Red raspberry is the bramble type most frequently affected. Infection generally occurs in low-laying locations in a field. While a number of soil-applied and foliarly-applied fungicides can be used, effectiveness is limited when used in wet locations; thus avoidance of poor sites is the main recommended method of management.

Verticillium wilt. This disease severely affects black raspberries. It can also affect red raspberries to a lesser extent, and also certain varieties of blackberries. Two different verticillium species affect brambles. Typical symptoms are dying canes with a bluish coloration, though often only a portion of a plant may show symptoms. Plants in heavy soils tend to be more affected, with cold wet springs implicated in more severe symptom development. The disease can survive in the soil for very long periods of time, and so it recommended to avoid replanting brambles in the same area once this disease is present.

Viruses

Viruses are systemic in plants and infections cannot be cured. With new techniques being developed to accurately identify viruses, and propagation techniques being used that keep the plant supply cleaner, the landscape related to viral issues is changing. Some viruses that had been common in bramble plantings are now rarely found, while other newer ones have arrived on the scene. A 2018 PA survey of bramble plantings and wild bramble plants in Pennsylvania, with 160 samples submitted to USDA-Corvallis virologist Bob Martin, found 54 samples testing positive for a virus, but only 9 of these infected by more than one virus. The most common one by far, blackberry chlorotic ringspot virus, is widespread in wild plants and also affect roses and apples. The best method of control is to start out with clean plants by using a nursery that employs virus-testing and tissue culture. Symptoms of viral infection do not typically become apparent until two or more viruses are present in a plant. Remove plants that show suspicious symptoms such as leaf mottling and disfiguration.

Nematodes

Various species of nematodes have been implicated in the decline of bramble plantings. The best solution is prevention, so conducting a nematode test prior to planting is recommended especially if prior plantings exhibited low vigor with no otherwise identifiable cause of poor growth.

"UNDER THE GROUND" FIRST YEAR RESULTS

Tanya Lamo & Alicia Anderson
Penn State Extension
Tanya Lamo
670 Old Harrisburg Rd #204, Gettysburg, PA 17325
Tel20@psu.edu

Alicia Anderson
724 Phillips St #201, Stroudsburg, PA 18360
axa1389@psu.edu

Presentation summary
2019 launched the pilot year of Penn State Extension's new marketing program, "Under the Ground". This network based secret shopper program creates the opportunity for agricultural store owners to receive feedback on their storefront's displays, signage, customer service, and overall appearance. This presentation will go over the program experience since it started this past spring.

How the program works
In the winter months storefronts signed up to participate for the upcoming year. In May, all businesses that signed up received a "Tool Kit" to launch the seasonal program. This included a map of all participating storefronts, a link to the store visit survey, and product marketing examples from other small businesses.

An initial webinar was held for all participants to go over the survey process and answer any questions.

From May of 2019 through April of 2020, storefronts are reviewed by their peers along with Penn State Extension Marketing Specialist and volunteers. These reports, along with a quarterly newsletter, are mailed out at the conclusion of four designated review periods.

A webinar was held in the summer looking at current trends that may impact the agricultural business community. This helps business owners stay on the cusp of societal landscape changes.

Tanya is a Penn State Extension Educator focusing on ag entrepreneurship, marketing and leadership. She assists small businesses in identifying ways to diversify, expand and market. Encouraging leadership in the workplace, Tanya helps businesses refine customer service skills, employee training and overall business experience. She also works to create opportunities for businesses to expand their professional network.
Prior to Extension, Tanya gained 7 years of teaching experience working with adults and youth with special needs. She holds a Bachelor's degree from Delaware Valley University and is currently pursuing a Masters Degree at Penn State University in Corporate Innovation and Entrepreneurship.

Alicia Anderson serves as a Sustainable Agriculture and Entrepreneurship Educator based out of Monroe County. She comes to Penn State Extension with a Bachelor of Science from Central Michigan University and an M.B.A. with a concentration in Supply Chain Management from Eastern Michigan University.
As an active contributor to the start-up of a food hub in the Northeast, she brings experience in local food logistics, producer coordination, system development, implementing software solutions, and production planning. Alicia has been working in the fields and pack rooms on a diverse range of sustainable farming operations since 2010 and continues spending time on farms in her free time.
Alicia also brings first-hand experience in small business and market development with a focus on long-term strategy for expansive community engagement.

Networking is another focal point of this subscription. Participants have access to an online community through Slack, received discounted tickets to the annual Are You Crazy Retail Farm Market Bus Tour, and received complimentary tickets to a networking dinner.

Figure 2: Marketing materials for program

2019-2020 subscriptions

This past winter we had 23 businesses sign up for the season. These subscribers are located in a 19-county segment in the eastern part of Pennsylvania. The large variety of storefronts that are involved produce items such as vegetables, fruits, cut flowers, dairy, cured meats, pies, wine, hard cider, baked goods, canned goods, and/or alpaca fiber items.

This large variety of production expertise creates opportunities for potential future relationships amongst store owners.

2020-2021 program plans

Through feedback we've received from the first two quarters, we'll be changing the secret shopping component this upcoming year to incorporate customer feedback and rely less on peer-to-peer visits. Although expressing the value of seeing other operations, the time constraints of a business owner were often a barrier to secret shopping participation

BUILDING A GREAT WEBSITE FOR YOUR SMALL BUSINESS

Danielle Gaebel
Superfine Social
PO Box 203, Narrowsburg, NY 12764 | danielle@superfinesocial.com

You have less than 15 seconds to capture a visitor's attention on your website's homepage. That's why the best websites are designed to be clean, easy, clear; designed with the goal of serving your customer - not your brand. A great website delivers a good experience on desktop and mobile; providing an accurate depiction of the products or services you offer.

Yes, it's 2020 and social media is where it's at - but… websites are still relevant and your business should have one. Websites are like a guide - they answer the questions your customers have so that they take the next step - connection and/or a sale.

At the conference, we'll dive into the elements below and take a look at websites that are doing it right - along with those who aren't. **If you would like the chance for feedback** on your website, please email danielle@superfinesocial.com by January, 24, 2020. Presentation slides will be available to all attendees.

Why You Need a Website

- Makes it easy for customers to learn how you help solve their problems and pain points
- Builds credibility and trust
- Helps you get found online
- Eliminates product/service confusion
- Does the pre-selling for you
- You can use it to produce revenue
- You own the domain and property
- It's an affordable marketing tool

Stats to Know

- First impressions are 94% design-related. - ResearchGate
- 46% of people say their number one criterion for determining the credibility of a company is the website's design. - Stanford's Persuasion Technology Lab
- 38% of people will stop engaging with a website if it's unattractive. - Adobe
- User experience can be the deciding factor in whether your customers choose your brand over a competitor. - Nielsen Norman Group

Elements of Great Web Design

- Starts with your customer
- Easy to navigate

Danielle is on a mission to help small businesses succeed using the power of social media and digital marketing. Co-founder, Social Media Coach & Marketing Strategist, Danielle began her career in marketing 22 years ago working with small businesses across various platforms including print, radio and now digital. Danielle has become known as the marketing "go-to" for all thing's social media and web. Along with her business partner and wife, Jennifer, the duo spearhead social media and digital marketing for the Sullivan Catskills Visitors Association, Narrowsburg Chamber of Commerce and a variety of farm, food, lifestyle, and destination brands. Danielle is also a former foodpreneuer. After several health issues and lifestyle changes, she followed her passion of healthy living and created Natural Contents - an organic pre-packaged food business turned lifestyle blog and cookbook. In 2013, Danielle was recognized as "Woman of the Year" by the Professional Women of Sullivan County. In 2012, Danielle and Jennifer were recognized as "Women Who Make a Difference" by SUNY Sullivan Community College. Danielle serves on the Narrowsburg Chamber of Commerce Board of Directors and the Sullivan Renaissance Steering Committee. She resides in the Sullivan Catskills with her wife, two teenage children and two loveable pups. If you happen to see her around, she'll most likely have an iPhone in-hand documenting the stories of her clients and community.

- Great photos and clear text
- Designed for mobile
- Prominent CTA's (calls to action)
- Captures email addresses
- Uses an opt-in
- Features reviews/testimonials
- Easy to find contact info
- Social channels connected
- Matches the brands style
- "Above the Fold" USP (unique selling proposition - what you do, who you work with, what you're going to help them achieve)

Options for Building a Website

- DIY or Hire a Designer
  * DIY: Are you computer savvy? Do you have an eye for design? Do you have the time to build a website?
  * Hiring a Designer: What's your budget? Will you need them to handle your updates or would you like to make the updates yourself?

Tips

- Choose the right platform based on your needs and goals
- Choose a platform that you can maintain - unless you have a budget to outsource
- Don't hire your friend who built websites in the 90s
- Don't hire a cheap agency from oversees
- Don't spend more than you need to
- Do ask to see examples of work
- Time is money. Remember that before you decide on the DIY approach

Website Platforms

- **Squarespace**: Perfect for all businesses, very easy to update, often more affordable than hiring a WordPress designer.
  * DIY is possible depending on your skill set
  * Avg. Designer Cost $2000-$6000 plus $215-$500 in hosting fees per year
- **WordPress:** Robust in features, great for large businesses with heavy content.
  * Not a good DIY option
  * Avg. Designer Cost $4000-$8000 plus $350-$700 in hosting fees per year
- **Wix:** DIY - easy to edit templates and a large variety to choose from.
  * No designer fees. Avg. Cost $265-$468 per year
- **Weebly:** DIY - easy to edit but limited templates.
  * No designer fees. Avg. Cost $150-$325 per year
- **Google**: DIY - super easy to create but limited in design and features.
  * Free

CONSUMER TRENDS

Kathy Kelley
Department of Plant Science
and
Claudia Schmidt
Department of Agricultural Economics, Rural Sociology and Extension Education
The Pennsylvania State University
University Park, Pennsylvania 16802

During our session, we will present consumer and product trends, including relevant categories, international cuisines, and flavors, and discuss marketing strategies small and medium-sized produce growers and retailers can implement to meet the needs and wants of likely buyers.

U.S. generations

Before we describe the consumer and food product trends for this new year, here is a brief primer on U.S. generations, their ages in 2020, and the percentage of U.S. population in each. Many of our purchasing decisions are based on our psychographics (attitudes and beliefs) and our behaviors (what we do in a situation); however, researchers and associations have detected differences in food consumption and trends based on this characteristic.

While there are slight differences in the years that mark the beginning/ending for each generation, according to the PEW Research Center (Dimock, 2019), the age ranges that define them (adjusted for 2020) are as follows:

- Generation Z – under age 23 (various reports state different years as to when the generation ends)
- Millennials – age 24 to 39
- Generation X – ages 40 to 55
- Boomers – ages 56 to 74
- Silent/Greatest generations – age 75 and older

Pertaining to the percentage of consumers in each generation. Data published in the first quarter of 2017 (Nielsen, 2017) provided the percentage of consumers in each generation:

- Generation Z –26%.
- Millennials –22%
- Generation X –20%
- Boomers –24%
- Silent/Greatest generations – 9%

Now, what are we eating?

Specialty Foods

While "there is no clear definition for specialty food…However, specialty foods can be loosely defined as premium-priced food products that provide an added-value appeal" (specialtyfoodcom). Examples of specialty foods include plant-based meat alternatives, plant-based milk, snacks, and refrigerated sauces, salsas, dips, and condiments. And, though the phrase "specialty food" may invoke a more expensive or exclusive food item, between 2013 and 2017, sales of specialty foods have grown 7.2% annually, with projections for 2018 through 2023 expected to continue, but at a slightly lower annual rate of 5.9%. Also, approximately 74% of U.S. consumers reported purchasing

Kathy Kelley is a professor of horticultural marketing and business management in the Plant Science Department at The Pennsylvania State University. She joined the faculty in 2001 and has a research, extension, and teaching appointment.

Claudia Schmidt is an assistant professor of agricultural economics in the agricultural economics, rural sociology and extension education department. She joined the faculty in 2018 and has a research and extension appointment.

specialty foods in 2019. When segmented by generation, 84% of millennials and 75% of Generation X bought these food items (Specialty Food Association, 2019).

Small and med-sized produce operations may not want to purse value-added processing on their own, or do not have easy access to a manufacturer to process fresh fruits and vegetables. However, it is still worth considering how value-added processed snacks can fit within your product offering, either through a private-label option, which has experienced growth for the past few years (Kvidahl Reilly, 2019) or by retailing established brands of snacks.

Not only do specialty food purchasers select a product based on type or flavor, these consumers have an interest in transparency with approximately a third indicating that they "like to learn the story about brands/products they buy" (Specialty Food Association, 2019). Additionally, there is evidence that particular product claims matter to specialty food consumers. Baby boomers, for example, tend to favor natural, organic, and plant-based foods (e.g., almond milk, coconut yogurt, eggplant bacon), while Gen Z: "Most concerned about fair trade, care less about GMOs than previous generations" (Specialty Food Industry, 2018).

Plant-Based Diets

Plant-based diets are truly gaining a following with options ranging from casual plant-based meat alternative consumers to consumers who follow a vegan diet. Here are a few statistics that demonstrates the shift in consumption to a more plant-centric diet.

- Between 2014 and 2017, the number of Americans who indicated they were vegans increase by 600% (Matthews, 2018).
- A quarter of U.S. Millennials between ages 25 and 34 claim to be vegetarians or vegans (Parker, 2018).

Some consumers might view these lifestyles as being restrictive or difficult to follow. Thus, flexitarianism, first identified in 2004 (Hesser, 2004), describes consumers who want to include meat and dairy in small amounts, but follow a vegetarian or vegan diet at least 75% of the time (http://bit.ly/35FkR26).

Regardless of which diet a consumer follows, it is highly likely that a fair percentage of your customers are filling their shopping carts with considerably more of produce that some other food categories such as meat and dairy.

Snacking

According to The Hartman Group's 2016 The Future of Snacking Report, 91% of survey participants indicated that, on average, they ate three meals and frequently snacked throughout the day, while 8% responded that they did not follow the traditional "three meals a day," but instead relied entirely on snacks (http://bit.ly/2sEAzvX).

Healthy eating not only resonates with consumers when shopping for ingredients for meals they cook but also when selecting snacks for their household. Snacking, which once was synonymous with unhealthy or "empty calorie" options, has evolved with more focus on "healthier alternatives with functional benefits" (Burrell, 2019). A study conducted by Lightspeed/Mintel revealed that 41% of adults responsible for the food and beverage shopping for the household were "trying to eat more healthy snacks." Additionally, consumers age 18 to 34 are "more frequent snackers" (Mintel Group, Ltd., 2019), and they "are more likely than any other generation to snack [at least] four times a day" (Fromm, 2017).

References

Burrell, H. 2019. 2020 food trends: what changes will the food industry see in the new year? FoodBev Media. Retrieved from: https://www.foodbev.com/news/2020-food-trends/

Dimock, M. 2019. Defining generations: Where Millennials end and Generation Z begins. http://www.pewresearch.org/fact-tank/2019/01/17/where-millennials-end-and-generation-z-begins/

Fromm, J. 2017. What brands need to know about modern Millennial snack culture. Forbes.com Retrieved from: https://www.forbes.com/sites/jefffromm/2017/02/08/what-brands-need-to-know-about-modern-millennial-snack-culture/#48404a631885

Hesser, A. 2004. Flexitarians. The New York Times Online. Retrieved from: https://www.nytimes.com/2004/12/26/weekinreview/flexitarians.html

Kvidahl Reilly, M. 2019. Fueling private label snack and bakery sales through innovation. Snack Food & Wholesale Bakery. Retrieved from: https://www.snackandbakery.com/articles/93505-fueling-private-label-snack-and-bakery-sales-through-innovation

Matthews, R. 2018. The vegan trend: Why so many people are changing their diets. https://chicagodefender.com/2018/05/03/the-vegan-trend-why-so-many-people-are-changing-their-diets/

Mintel Group Ltd. (2019). Food and drink shopper US, November 2019. Accessed 19 December 2019.

Nielsen. 2017. The Nielsen U.S. total audience report: Q1 2017. https://www.nielsen.com/be/en/insights/reports/2017/the-nielsen-total-audience-report-q1-2017.html

Parker, L. 2019. State of the Industry 2019: Puffed and extruded snacks from growth through product diversity. Snack Food & Wholesale Bakers. Retrieved from: https://www.snackandbakery.com/articles/93254-state-of-the-industry-2019-puffed-and-extruded-snacks-find-growth-through-product-diversity

Purcell, D. 2019. Top Food Trends 2019. Specialty Food Magazine, 49(1): 34, 36, 38, 40-42, 44.

Specialty Food Association. 2018. The state of the specialty food industry 2018. Specialty Food Magazine, 48(3): 89-104.

Specialty Food Association. 2019. The state of the specialty food industry, 2019-2020 edition. Specialty Food Magazine, 49(3): 105-116

GETTING CUSTOMERS IN THE DOOR & KEEPING THEM COMING BACK FOR MORE

Karen Paulus
Paulus Mt. Airy Orchards
522 E. Mt. Airy Rd., Dillsburg, PA 17019
Karen@PaulusMtAiryOrchards.com

Getting them in the door = Marketing

Keeping them coming back for more = Experience

The role of marketing is to get people in the door. It doesn't guarantee anything more than that. It's a critical step that definitely needs a lot of attention, but it's not the only step. Marketing does not equal sales. After your potential customers step in the door, they need a great experience. A great experience leads to great sales. How do you give a great experience? You need the right products, visually appealing displays, a clean and organized store (both inside and out), and a well-trained staff.

Marketing: (Great Calendar, Great Communication, Great Cash)

- Great Calendar – Have something special each week; something big each month
  - o Great Apple Sale (January, February, March) – End of season sale to move inventory
  - o Reading Certificates (March) – teachers contact you with their name, email, school, and grade they teach. You email certificate for free admission and the teacher prints for class. Bonus – the child needs someone to bring them so they'll purchase at least one admission and you get teacher email addresses to promote tours!
  - o Festivals – Our festivals benefit a charity to support our local neighbors in need (New Hope Ministry, Ecumenical Food Pantry, CURE International). We offer free free wagon rides, live music, craft vendors, in-store specials
    - ▪ Strawberry Festival and 5K (June)
    - ▪ Blueberry Festival and All-You-Can-Eat Pancake Breakfast (July)
    - ▪ Peach Festival and All-You-Can-Eat Pancake Breakfast (August)
  - o Name of the Day (May-August) – social media posts for something free each day.
  - o Classes
    - ▪ Little Farmers, Cooking/Baking, Crafts – give an in-store discount for day of class!
  - o Tours (Summer and Fall) – give a bounce back pass!
  - o CSA (May-September) – any kind of subscription program
  - o Fall Festival Weekends – free wagon rides, pick-your-own apples and pumpkins, corn maze & PlayLand, live music
  - o 12 Days of Christmas (December) – deep discount on one item each day for 12 consecutive days
  - o National Day of… [National Scavenger Hunt Day (May 24), National Donut Day (June 5), National Selfie Day (June 21), National Girlfriends Day (Aug 1), National Talk like a Pirate Day Sept. 19), National Cookie Day (Dec 4), etc.] (Any month) – special offer based on the day. http://holidayinsights.com/
- Great Communication: Email Newsletter, Social Media, Bag Stuffers, Calendar of Events posted in store

Karen Paulus and her husband, Dan, own and operate Paulus Mt Airy Orchards in Dillsburg, PA. They purchased the orchard in 1999 and have a goal of adding something fun and new each year. Karen has a B.S. degree in Chemistry from Salisbury University, MD and has previously worked in education at high schools in Delaware and Pennsylvania as well as an adjunct instructor at Messiah College in PA. She and Dan have 3 children, Matthew, Lauren, and Jessica.

- o VALUE more than a sales pitch
  - Recipe, Upick Availability, Funny Stories, Cartoon, Your Farm Story, Calendar of Events, Staff Spotlight, Staff Picks
- Great Cash: Gift Certificates
  - o National Night Out: Free Admission for 2 to Corn Maze & PlayLand
  - o Health Fairs: $5 Gift Certificates
  - o Way to help organizations raise funds https://paulusmtairyorchards.com/raising-funds-can-help/

Experience: (Great Staff, Great Products, Great Fun, Great Incentives)

- Great Staff
  - o Group Employment Auditions
  - o Monthly Management Meetings
  - o Monthly Staff Meetings
  - o Daily Huddles/Small Group Coaching
  - o Notes of Encouragement
  - o Staff Facebook Page
  - o Pizza – Chick-Fil-A – Coffee/Donuts….What can you give?
- Great Products & Displays
  - o Home Grown & Local Produce
  - o Private Label
    - Shawnee, Farmer's Choice
  - o Other Food Items
    - Greenstar, Dutch Valley
  - o Gift Items
    - Norpro, Smoky Oak Candle, Cheap Carl
  - o Farm Branded Items
    - Mugs, T-shirts/sweatshirts, Keychains, Magnets, Ornaments, Stickers, Postcards, Pens, etc.
- Great Fun
  - o Pick-Your-Own
  - o PlayLand (Admission) – Corn maze, Jumping Pillow, Pedal Karts, Tube Slides, etc.
  - o Free Play Area - Tractors, Giant Chair, Playground, Checkers & Tic-Tac-Toe
- Great Incentive to Return
  - o Thank You Program – can be as simple as index cards! You keep cards at your store. After 6 purchases the card is full. On 7th purchase customer receives 10% of the money they have spent back as a discount towards current purchase. Rewards higher dollars spent and more frequent visits. Also a great way to collect emails! We pay our cashiers $0.50/email.
  - o Bounce Backs – Can be for anything.
    - Pick-Your-Own: Get $1 off something from the deck for every 5lbs berries picked.
    - Tours: free return admission
    - Christmas Cash or any kind of Bounce Back Bucks

FIRST FIELD - OUR STORY OF DEVELOPING VALUE ADDED TOMATO PRODUCTS

Theresa Viggiano
Founder and CEO, First Field
92 N. Main St
18C
Windsor, NJ 08561
theresa@first-field.com

Early Days // Why Value-Added?

--Using your and your network's agriculture output to increase the value of your hard work

First Field started with a small organic farm, an honor-system farm stand, and an idea to turn our bumper crop of our tomatoes into something we could sell year round. This is not a new concept in NJ; we have a long history of exceptional growers, processors and tomato products. Yet, as agriculture and big food systems evolved, the number of both growers and value-added products that came directly from their farms decreased over time. As we grew First Field, we began to rebuild these same relationships over again with growers, the extension service, and the USDA, all to answer a very simple yet complicated question--could we make this work? Through our journey to find out, we have learned a lot about our state's tomato history, our growing community of customers, our farmers, and how to stay true to our mission. We do know one thing for sure—the higher prices and more diverse customer base for a high-quality processed item can in many circumstances make more sense that selling the fresh item unprocessed.

Launching the first product

-- Find your first retailer and building a strong relationship with the buyers

Once we had our first product, Tomato Ketchup, we started to sell it to a local retailer (one where we still continue to test new products). We had three flavors of ketchup at the time and made them in the evenings after work a few times a month at Elijah's Promise, a non-profit community-focused culinary school, soup kitchen, and early supporter. We still grew all our tomatoes that year and then had our first chain retailer, Whole Foods Northeast, contact us to see if we could supply all of their stores with our Original Ketchup.

Scaling that first product: Supply Chain

-- Once you know there is demand, look at your supply chain

The amount of product we needed to make required an in-depth look at our supply chain—mainly, our own farm's output. We knew we couldn't manage on a single acre of tomatoes, so connecting to the extension service was essential to making sure we had a high quality supply of tomatoes. We also had a lot to learn about conventional, large scale tomato growing, and began a trial by fire to find our way.

Scaling that first product: Processing and Packaging

-- How will you process your product? What regulations do you need to know about?

We continue to learn about how to be more efficient about our processing. It can be extremely challenging to not only have to look at how the harvest is faring while at the same time making sure everything is lined up to support the entire next year's sales efforts. Reaching out for help is essential during the first few years, and beyond. The Rutgers Food Innovation Center was instrumental in helping to navigate the relatively new Food Modernization Act requirements, as were the patient and steady growers we worked with. The key for us has been to try to plan ahead and anticipate problems and potential solutions before they happen, while also recognizing that there is an element of constant surprise to any agricultural-based business that will push a business to innovate through its challenges.

Theresa Viggiano is CEO and Co-Founder of First Field, a value-added company in NJ dedicated to working directly with regional growers to make premium pantry staples. She has received two USDA grants to support the work of First Field, in both soil health and value-added marketing. She has a BA from Indiana University in Sociology, an MA from University of Kentucky in Medical Sociology, and was a PhD candidate in Sociology at Rutgers University, and worked at Rutgers at the Institute for Health, Health Care and Aging Research in the area of mental health services until she left to tend to tomatoes full time. She and her husband Patrick Leger, Co-Founder and CFO of First Field, live in Skillman, NJ with their two young sons.

Sales & Marketing

--The single most important thing you can do to promote your products is to be authentic, and put your story in front of retailers.

We are and continue to be a grassroots brand, meaning we mainly rely on our company's integrity and trustworthiness to spread the word and launch in new sales channels, instead of traditional expensive marketing. This is integral to the success of getting your product and brand out there to retailers. Buyers at retailers, both small and large, know their customers. And their customers are demanding more local foods, more traceability, and more trustworthiness in the products they are buying. Just by producing a local item you will have their attention, as shelves continue to add locally and directly sourced items. These products, however, will demand your attention while you are launching them, both in telling the story (marketing) and knowing who your customers are (sales). Online sales and social media are becoming essential to new brands, so being able to clearly articulate your story and product highlights to the customers who support farms, brands and products like yours will be a constant demand on your time during the early years.

Your Customers

--Who they are, and why you are important to them and they are important to you.

While we were meeting with growers and figuring out how many tomatoes we needed, we quickly found out that one of the integral aspects of being a value-added company was projecting demand. Tomatoes have a short season, but value-added tomato products are sold all year. Building relationships with our buyers was important, and we quickly learned from them that we needed to get in front of our customers to tell our story, too. Whether it's handing samples out at a regional fair, doing a demo at a local retailer, or making sure you're finding creative ways to use social media to tell your story with an authentic voice, making sure your brand is in front of your customers is essential to continued sales. You need to get a clear idea of who is buying your items, and where they shop. Being able to identify and understand regional and demographic demand will help ensure you're meeting your customers where they are, and not wasting valuable time and resources selling to the wrong customers. Listen to your customers, reach out to them, and be open to their feedback of what they're looking for.

Your Brand and Mission

--Use your social and environmental commitments to help form what you do.

Our first partner grower, along with Jack Rabin at the Rutgers Extension Service, helped us with an early grant project, a USDA Sustainable Agriculture Research and Education grant, to test whether or not using a Rodale Roller Crimper could replace herbicide to mechanically kill a rye cover crop. Since our first farm was organic, finding ways to support soil health is still a very important part of what we do. But we also fully recognize the constraints and economic challenges of a commodity-based growing environment, and a sustainable business is not sustainable if it is not economically sound. Use your history, values, and commitments to your community to find your path in how you shape your brand—whatever drives what you do. It's part of your story, and it's also why your customers and community want to support what you're producing.

HAZELNUTS AS A VALUE ADDED PRODUCT

Megan Muehlbauer
Rutgers Cooperative Extension of Hunterdon County
314 State Route 12, Building#2, PO Box 2900
Flemington, NJ 08822-2900
Email- muehlbauer@njaes.rutgers.edu

David Hlubik
Rutgers University
59 Dudley Road, New Brunswick, NJ 08901
Email- djh222@scarletmail.rutgers.edu

Hazelnuts are garnering significant interest as a crop in the United States due to increasing cultivation in the Pacific Northwest, breeding efforts in the East and Midwest, and world-wide demand for kernels. Over the past 20 years, Rutgers University's hazelnut research and breeding program has been studying hazelnuts and developing new cultivars that are well adapted to New Jersey and the Mid-Atlantic region of the United States. These new cultivars are resistant to the disease Eastern Filbert Blight (EFB), a fungal pathogen which has historically been the major limiting factor to hazelnut cultivation in the eastern United States. The first cultivars released from the breeding program (Raritan, Monmouth, Hunterdon, and Somerset) are currently being produced in tissue culture and trees will start to become available from commercial nurseries in 2021. While wholesale in-shell hazelnut prices have ranged from $1 to more than $2 a pound in recent years, local growers have the potential for much greater earnings by creating value-added products for sale in local markets. With over 20 million consumers in the New York City/Philadelphia area alone, the market potential for value-added products appears very high. Hazelnuts are currently in high demand, with a wide variety of product options that include candies, cookies, nut butters and spreads, oils, ice cream, and many other items. Interestingly, most hazelnuts currently sourced for these products are imported (largely from Turkey), leaving a lot of room to utilize domestic sources. In addition to more complex value-added products, on farm shelling of nuts for kernel sale is another avenue for higher-priced sales, as they could be sold directly to consumers, restaurants, confectionary shops, and/or bakeries. Given the phenology of this crop, it could also lend itself for pick your own operations since nut maturity coincides with other orchard harvests in the early fall. Additionally, in-shell hazelnuts can be stored for over a year after harvest, allowing farmers to sell retail products throughout the year or when wholesale prices are highest

David Hlubik. I am a second-year graduate student at Rutgers University under the direction of Dr. Thomas Molnar. The main research topic that I have been investigating is the use of American-European hybrid hazelnut trees as pollinizers for orchards in the eastern United States. I am investigating nut qualities, female and male flower characteristics, and cold tolerance of these hybrid trees using a variety of phenotyping methods. This project will help to ensure that there are high-quality pollinizer varieties available for farmers alongside the main production varieties that the breeding program is currently releasing. I am also looking at the use of environmental sensors in the field to monitor weather conditions and tree health, and connect these measurements to plant characteristics observed by phenotyping.

Megan Muehlbauer. Megan is the Hunterdon County Extension Agent III. The focus of Megan's extension work is on tree and small fruit production in northern New Jersey. She received her PhD from Rutgers University in the hazelnut breeding program, and has been involved in a number of field projects involving a range of crops including apples, peaches, pears, hops, wine grapes and hazelnuts.

CUT FLOWERS AS A LOW-COST VALUE-ADDED OPTION

Brendon Pearsall
Pearsall Flowers, Highstown, NJ

For farmers who are interested in converting a portion of their crop into value-added products one of the major barriers is the expense associated with developing the kitchen facilities necessary for processing. In New Jersey in particular there are many regulations that can discourage a grower from pursuing value-added production. Kitchens must be built in accordance with local codes, zoning issues can present a problem, and regular health inspection and certification requirements can add up to a lot of extra cost before you've even canned your first tomato.

As an Agriculture student at Rutgers University I had the opportunity to intern on a local family farm, Giamarese Farm and Orchards, in East Brunswick, New Jersey. Last February, the farm's owner, Jim Giamarese, lent me the use of a small piece of land to attempt my own farm operation. I only had about a third of an acre to work with, so I wanted to choose a crop that would maximize my profitability on small acreage. My mind turned to value-added products as a way to get the most out of my piece of land. I thought that I could make salsas or tomato sauces out of my produce. After a little research I discovered that New Jersey's stance on "cottage industries" was not favorable for what I wanted to do. The more I researched, the more I realized that if I wanted to get the most out of my small parcel, and incorporate a value-added element, then I only had one real option, cut flowers.

The term "specialty cut flowers" refers to any of the wide variety of seasonal summer flowers that do not ship well and so must be sourced relatively locally. These include sunflowers, zinnias, lisianthus, dahlias, ageratum, celosia, cosmos and more. There is an increasing level of awareness among consumers regarding how far products travel to reach them. Building off the popularity of local food movements, the #grownnotflown campaign has become prominent among flower growers. This campaign brings attention to the fact that the vast majority of our commercial cut flowers are flown in from the Netherlands, Columbia, Kenya and Israel and helps to inform customers and encourage them to buy locally grown flowers.

Growing any of these varieties of flowers on their own can be a profitable use of small to medium acre fields. For additional profits value-added elements such as bouquets and arrangements can greatly boost sales. **You do not have to be any kind of artist to make saleable bouquets!** There are simple mechanical techniques that can be used to create attractive flower arrangements. It is the same as following a recipe, but it doesn't require an expensive certified kitchen space. You need the right balance of focal flowers, fillers, spikes, airy elements and greenery. These techniques are difficult to describe in text but there are plenty of online resources to get you started. Floret Farms in Mount Vernon, Washington has developed a website (floretflowers.com) with EXTENSIVE resources for the production and sale of cut flowers and bouquets. There are plenty of other online resources, including instructional videos on YouTube.

Production

It's important to note that when I first began planning out my cut-flower operation I had next to zero flower growing experience, helping my mother in her garden as a kid was the extent of my contact with flowers. I had only made one flower arrangement in my life, in a horticulture class at Rutgers. I was not "passionate" about flowers, I was passionate about farming. So, I approached cut flowers like any other crop. I learned about intensive production systems, researched varieties, planned out successions, and bought seed. I largely followed established guidelines and seed packet instructions, and incorporated advice from other local flower farmers. Most cut flower varieties can be grown very intensively, with spacings of only 6-9 inches and the ability to get multiple harvests out of the same bed with proper succession planting. This small space intensity combined with the high demand for locally produced flowers is why you will see per acre cut flower sales figures of $30,000-$40,000. My sales from my third of an acre fell comfortably within this range, in spite of the MANY mistakes that I made having never done anything like this before.

I grew all of my flowers on black plastic mulch with drip irrigation that was put down with 10-10-10 fertilizer. Additional liquid fertilizer was supplied via drip irrigation throughout the rest of the growing season. If you are using liquid fertigation for your vegetable crops already, you can use the same liquid fertilizer on your flowers so you don't have to split lines, this is what every grower I talked to did. Most of my varieties were planted with staggered 9-inch spacings. My beds were 36" wide so they could comfortable support 3 rows. I only had a single drip line down the middle, though I did not notice any water related issues with the outer plants I would use two lines in the future.

Planting is one of the more time-consuming aspects of flower production due to the large amount that you can fit in a small space. Most of my flowers were direct seeded, a few were planted from plugs. I did not have significant up-front capital to afford many plugs, and so opted for seeds. The down side of this was significant slug damage to seedlings early on which delayed some of my first harvest times. In order to mark out and make holes for planting I used a three-foot wide piece of sheet metal with 2-inch holes drilled in for the correct staggered spacing. I made two of these templates, one for 6-inch spacing and one for 9-inch spacing. These would be laid on top of the black plastic and a propane torch was used to burn the holes. This allowed me to lay out my planting holes very rapidly and with a consistent pattern.

Pests and Diseases

Insect pests other than the slugs were not a huge problem for me and so I opted not to spray. This became a positive marketing point for many of my customers who were glad to hear that no insecticides were used. I did get some minor Japanese Beetle damage to my zinnias and dahlias but the zinnias grew out of it and my dahlias had bigger problems. I did see a few sunflower moths around later in the season, but since I was cutting sunflowers as they opened there was no chance for them to cause damage. I used organic slug baits early on to deal with the slug problem.

Disease was a bigger issue, I lost quite a few zinnias and celosia to Alternaria Leaf Spot, and my many of my dahlias were killed by bacterial stem rot due to my poor timing for pinching them back. Powdery mildew is what eventually put an end to my zinnias, I sprayed alternating treatments of Daconil and Quadris to slow down the disease progression.

Harvest and Post-Harvest

I would generally harvest every 2-3 days. I sold at two farmers markets and would harvest a day or two before the market so that I would have the time to process the flowers and make bouquets. Harvesting was done with a sharp pair of pruning shears and I would keep rubber bands on hand to bunch as I went. Bunches of 5 were standard for sunflowers and cockscomb celosia, and bunches of ten were standard for most other flowers. Stems were cut at a 45-degree angle, excess leaves were stripped off, and finished bunches were placed in a bucket of clean water with one packet of FloraLife Express 300 added in. Refrigeration was not required since the time from harvest to market was so short.

Markets

I took advantage of multiple marketing channels in order to sell my flowers and arrangements. Direct sales through a pair of local farmers markets made up the bulk of my sales, but I also sold a small amount to a local wholesaler, a florist, through a farm store, and made several special-order deliveries to office buildings, parties, and even one wedding. I also sold 8 weekly CSA shares, 6 that were weekly bouquet deliveries, and 2 bucket share deliveries, which consisted of buckets of assorted bunches. Those customers who participated in the CSA model loved the weekly flower deliveries, and are eager to participate again.

I found that community farmers markets were far and away the best outlet for cut flowers and bouquets. Many customers were drawn to my section of the market by the abundance of flowers on display. If you're a fruit and vegetable grower, adding a robust display of cut flowers to your market stall creates a visual draw that can bring in customers to see what else you have, it's like having a billboard that sells itself! I had many customers who would return week after week to buy my flowers, and I would regularly sell out of everything I could transport.

My best-selling items were invariably my mason jar arrangements, one-quart mason jars with burlap collars tied around the rim. I would make small bouquets, around 10-12 stems, and place them sticking up out of the jar with some FloreLife treated water in the bottom. These would often sell faster than I could make them, and I had regular orders to deliver them by the dozens to one local office building. These easy, low-cost value-added arrangements made up the largest portion of my total flower sales, next to sunflowers.

For one last piece of advice, **SUNFLOWERS SELL**, people love them and they will pay well for big beautiful sunflowers. If you have a bouquet on your table that's not selling, stick a sunflower in it and it will sell. If you're not interested in value-added cut flowers at all, just take away this one piece of advice, grow a few rows of sunflowers, sell them through farmers markets, do pick-your-own, let people come take pictures in front of them. Flowers in general and sunflowers in particular are a great addition to any farm's portfolio.

YOUR AGRITOURISM PRICING IS WRONG, AND I CAN PROVE IT.

$1,000 per Attendee Guaranteed!

Hugh McPherson, Maize Quest
2885 New Park Rd, New Park, PA 17352
hughmc@mazecatalog.com 717-862-4691

"Want to make 20% pure profit next year? Go home and put up your prices."
– Rick Turner, The Big Sheep, UK

1. You are NOT a commodity. If you are in agritourism, you are specifically competing on the basis of experience. Experiences are NOT commodities.
2. Increasing prices IS the fastest way to increase profits. If your business is completely flat, you will increase revenue while doing the same amount of work.
3. Consumers are NOT economists. The average guest is not surveying the closest 10 farms, creating a spreadsheet, then evaluating the options rationally.

Not convinced? Let's do some math. If you welcome 1,000 guests and charge each $5.00 admission, you've generated $5,000 in revenue. If you charge $10 each, you can lose 50% of your attendance, and *still generate $5,000 in revenue.*

- How probable is it that 50% of your customers leave you at once?
- How many fewer employees do you need to handle 500 instead of 1,000 guests?
- If you only lose 25% of your attendance, you *increase revenue by 25%!*
- If only 100 people stomp off mad, *you're up 80%.*

How to make a BIG pricing change

Combo Pricing

- Invent retail pricing for each item, attraction, activity
- Add them all up
- Choose desired retail combo pricing
- Specifically market the total value and the amount 'SAVED'

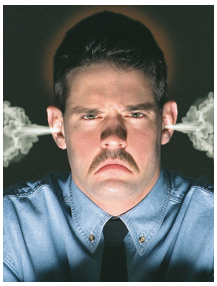
Tiered Combo Pricing

Use a Red Herring:

- Major attraction as a distraction
- 3-Tiers – Low, Med, High
  - General Admission
  - General + 1-time special
  - General + UNLIMITED Access
- Clear communication
- Staff training
- Full commitment

Hugh McPherson is the 5th generation at Maple Lawn Farms and returned from Penn State to start the Maize Quest Corn Maze & Fun Park in the late '90s before agritourism was a word! Maple Lawn Winery added fruit wines and hard ciders to the farm in 2016. Each season tens of thousands of guests visit the farm, maze and now winery to pick fruit and make memories. Hugh authored *"The 31-Day Workforce Turnaround"* in 2017 based on his experience managing seasonal and teenage workers. His latest book *"Customers Coming Out of Your Ears"* offers a reference guide of marketing ideas for farms and markets

Customer Feedback



- Honestly… It might be tough!
- Be Prepared
- Every day, know why you're doing this
- It'll get better, have faith, stay disciplined
- Remember, the most upset customers may just be porta-john fillers!

Conclusion

- Maize Quest Fun Park – Tiered Combo Pricing - 29% revenue increase 2014 to 2015, ZERO complaints.
- Blooms & Berries – NEW to admission - 53% revenue increase – Who cares about complaints?!
- *We'll take questions on pick-your-own admission, pumpkin pricing, and share stories on donut pricing, "Old Hugh's Fearful Mindset," and MORE!*

RISK MANAGEMENT FOR AGRITOURISM

Lynn Kime
Penn State Extension

Every agritourism operation should have a detailed and written risk management plan. There are many forms of risk management available for these businesses and may operation employ several forms and methods. These include, business structure, multiple types of insurance, and daily inspections during operations.

The business structure should be well thought out and possibly incorporate several levels of structure. Some operations still operate as sole proprietorships or partnerships and with the proper insurances, this may work. However; some operations will have multiple business structures with different entities owning each level of the business.

One business may own the land, and another may own the agritourism enterprise with another business owning and operating any food operations. This is a highly developed structure and should be seriously thought through. In the case of the agritourism enterprise, you should consult and attorney and your accountant when developing these structures. Your goal is to minimize both risk and taxation.

Each business structure should be fully insured and consultation with your insurance provider is a must. Describe in detail what your enterprise(s) does and the possible risks when talking to your insurance provider. You may have an insurance policy that closely resembles event insurance used by fire companies and county fairs. Keep in mind that each entity will need its own policy or policies.

Are you serving or offering food or refreshments? This requires another level of safety consideration. If you are offering the food or refreshments, do you have personnel food safety trained and are they trainings current? Even if another company is offering the food enterprise, are you listed on their policy as an insured? These requirements and listings must in writing to be sure all are covered.

Prior to beginning operations, have a trusted friend walk the property to see what hazards they see. You are too close to the operation to see what may be considered hazardous to others. When in operation, walk the property each day to be sure everything is in working order and all safety measures are being followed and in place. Can a toddler some how get close enough to a piece of equipment to be injured?

The presentation includes a listing of where to find additional information to consider when operating an agritourism enterprise.

Lynn Kime is a Senior Extension Associate and project coordinator for the Agriculture Alternatives publication series for the Department of Agricultural Economics, Sociology, and Extension Education of Penn State. He is also the team leader for the New and Beginning Farmer Team and works closely with educators to develop educational materials for this clientele. He works extensively in the area of budgeting for crops, livestock, and horticulture. Lynn also works in the areas of crop insurance education and is a co-author of the Your Future in Focus and Farm Sense courses.

FREE FACEBOOK IS DEAD. HOW TO WIN IN A PAY-TO-PLAY ERA

Hugh McPherson, Maize Quest
2885 New Park Rd, New Park, PA 17352
hughmc@mazecatalog.com 717-862-4691

FREE Facebook is DEAD

4. Proof 1: In Jan 2018, Facebook's Found Mark Zuckerberg said of an impending update to Facebook's algorithm, you'll see less public content like posts from businesses, brands, and media. That means YOUR business posts, will be seen LESS.
5. Proof 2: Automated Ads Arrive. Since your posts will be seen less, ads are easier than ever to make, so you can still be seen.
6. Proof 3: In 2017, our sunflower festival event was viewed by over 2million people. In 2018, less than 160,000.

Reactions to the 2018 Facebook Apocalypse? You could leave, but you'd be leaving 3.4billion people behind. Chances are, you are going to have to stay and play the NEW Facebook game.

How to WIN in a Pay-To-Play Era on Facebook

Plan to Capture Your Customers using the
Hierarchy of Awareness

- Visit to a page - Use a Pixel
- Click / Like / Response
- Email Address
- Mobile Number
- Mailing Address
- Order / Reservation / Sale

Use the A.R.C. Method for breaking your marketing program into Awareness, Remarketing, and Completion.

Awareness
"You probably wouldn't worry about what people think of you if you could know how seldom they do." – Olin Miller

Use Facebook Campaign – Reach

- Reach is for sheer volume of views.
- Frequency is the number of times each view individually sees your ad.
- Least expensive campaign
- Allows for Hand-Raising

Hugh McPherson is the 5th generation at Maple Lawn Farms and returned from Penn State to start the Maize Quest Corn Maze & Fun Park in the late '90s before agritourism was a word! Maple Lawn Winery added fruit wines and hard ciders to the farm in 2016. Each season tens of thousands of guests visit the farm, maze and now winery to pick fruit and make memories. Hugh authored *"The 31-Day Workforce Turnaround"* in 2017 based on his experience managing seasonal and teenage workers. His latest book *"Customers Coming Out of Your Ears"* offers a reference guide of marketing ideas for farms and markets

Remarketing

"*We have a relationship with our customer, and that relationship translates into sales.*" – Richard Hayne

Use Facebook Tool – Customer Audience

- Once someone "Raises her hand," segment by action
- Use different ads for this audience
- Make an offer
- Have a plan to make a sale

Completion

"It isn't over 'til it's over." – Yogi Berra

Use Facebook Ads – Customer Audience

- Remind
- Revive Interest
- Retrigger Desire

Sunflower Festival Ticket Sales Example

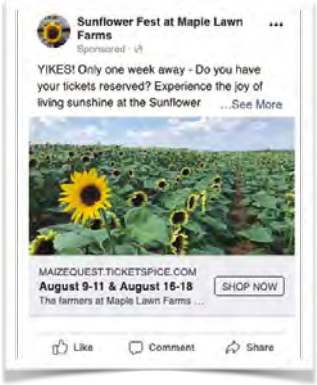
Our goal was to use this framework to sell tickets to our sunflower festival. We charge $25 per person for the festival on-site, so we had plenty of room to discount tickets in advance.

Results: We sold nearly 4,000 tickets, 98% in advance online. Here's the campaign structure and some of the actual ads we used to do it:

Awareness

Remarketing

Completion



Following the A.R.C. System

- We used flashy pictures of the festival to let people know we existed.
- We offered 30% for pre-purchasing online, for people who viewed the video or clicked to the website.
- We used a "Yikes!" reminder campaign to close the sale for people who clicked through to the ticketing page but didn't buy.

Conclusion

- Organic reach, no matter HOW amazing, reaches only 10% of your Likes.
- Facebook is now Pay-To-Play and they are so big, you cannot stop using the platform.
- You have to be thoughtful about your marketing spend, NO MORE Panicked Posts!
- Use the A.R.C. system to move people closer to purchasing as they interact with your ads, events or posts.

Need more? Get FREE tools, subscribe to Hugh's blog, and watch the FREE video series "The Cross-Marketing Multiplier" and "Adventures in Delegating" at www.HughMcPherson.com.

DIVERSIFIED VEGETABLE APPRENTICESHIP


Fullers Overlook Farm, Pennsylvania

The Diversified Vegetable Apprenticeship pairs beginning farmers with established growers to provide a guided pathway toward managing or starting a vegetable farm.

- Apprentices receive **2,700+ hours** of paid, on-the-job training & **200+ hours** of related coursework over **18 months**.
- Host farms **train the next generation** of sustainable farmers & gain access to a pool of **pre-qualified employees** invested in farming as a career.

Diversified Vegetable Apprenticeship is administered in Pennsylvania and surrounding areas.

Apply now at **pasafarming.org/dva**

PASA Sustainable Agriculture

This advertising space donated by the Pennsylvania Vegetable Growers Association.