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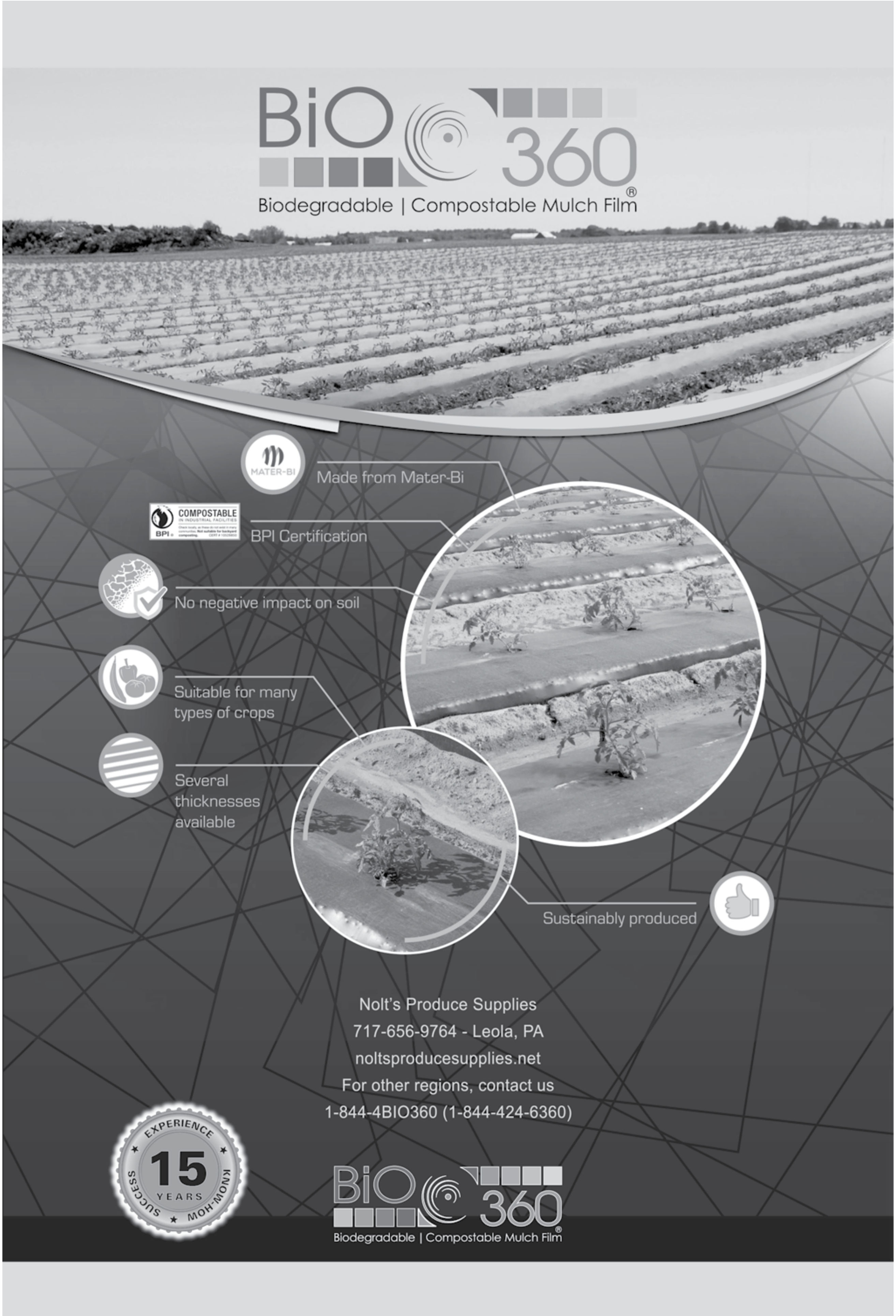
PROCEEDINGS

for the vegetable, potato, greenhouse, small fruit & general sessions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Pennsylvania Vegetable Growers Association

An association of commercial vegetable, potato and berry growers

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DOWNY MILDEW MANAGEMENT ON CUCUMBER AND CANTALOUPE

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Downy mildew is one of the most common and potentially devastating diseases of cucumber and cantaloupe in the northeast. The pathogen survives over winter in Florida on cucurbit crops growing there, then moves via wind-dispersed spores to new plantings to the north, infecting them and producing more spores that enable the pathogen to move further northward as the growing season advances, eventually progressing throughout the eastern U.S. Cucumber and cantaloupe are affected more than other cucurbit crop types. This is because the downy mildew pathogen exhibits host specialization and exists as two groups called lineages (clades), and the one affecting cucumber and cantaloupe is the first to develop and move through the eastern U.S. The lineage affecting squashes and pumpkin might not arrive in the northeast for up to two months later.

Guidelines on Managing Cucurbit Downy Mildew.

1) Select resistant varieties. Resistance was the main tool for cucumbers until a new strain of the pathogen appeared in 2004. Varieties with this resistance, which include most hybrids, have provided some suppression of the new pathogen strains present, but substantially less than the excellent suppression that was achieved against strains present before 2004. Fortunately there are now cucumber varieties with new sources of resistance that have exhibited good to excellent suppression. In a trial at LIHREC in 2021 with high disease pressure, control of downy mildew achieved was 57% for Bristol, 76% for Brickyard, 87% for TSX-CU231AS (experimental from Tokita), and 94% for DMR401. In other trials, the cantaloupe varieties Trifecta and Edisto 47 exhibited good to excellent control of both downy and powdery mildews.

2) Sign up to receive alerts about downy mildew occurrence and routinely check the forecast web site (http://cdm.ipmpipe.org) for predicted risk in your area and crops affected.

The forecast web site is an important tool for determining when fungicide applications are warranted. Cucurbit plants are susceptible to downy mildew from emergence; however, this disease usually does not start to develop in the northeast until later in crop development when the pathogen is dispersed by wind into the region. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. The pathogen is thought to only be able to survive over winter in southern Florida, and from there spreads northward. There has been no evidence that the pathogen is surviving between growing seasons where winter temperatures kill cucurbit crops (outdoors above the 30th latitude); however, recently both mating types have been found, but on different cucurbit crop types (Lineage 1 pathotypes are A1 mating type and Lineage 2 pathotypes are A2), thus there is the potential for the pathogen to produce oospores (sexual spores) that could enable the pathogen to survive in northern areas of the USA. The risk of downy mildew occurring anywhere in the eastern USA is forecast and posted three times a week. Forecasts enable timely fungicide applications. Anyone can subscribe to receive customizable alerts about new reports by e-mail or text message. When risk is forecasted for your area, look to see if the same or related crops are affected in the trajectory path to determine if your specific crops are at risk. This is important

Meg McGrath is an Associate Professor with Cornell University located at the Long Island Horticultural Research and Extension Center since 1988. She conducts research and extension activities on optimizing management of diseases affecting vegetable crops and herbs within organic as well as conventional production systems. Research topics include investigating fungicide resistance in the cucurbit powdery and downy mildew pathogens, monitoring occurrence of diseases, and evaluating management practices: fungicides, biopesticides and other organic fungicides, resistant varieties, cultural practices including reduced tillage and mustard biofumigation. Web pages include: https://www.vegetables.cornell.edu/pest-management/disease-factsheets/ and http://blogs.cornell.edu/livegpath/.

because of pathogen specialization and especially important if you do not grow cucumbers. Above the occurrence map there is a filter for selecting crop groups. Also, putting the cursor over a highlighted county will pop up when and on what crops reports were made there.

Report occurrences. Success of the forecast system depends on knowledge of where downy mildew is occurring; therefore, prompt reporting of outbreaks by growers is critical, which can be done at http://cdm.ipmpipe.org or an extension specialist can be asked to post.

3) Inspect crops routinely for symptoms beginning at the start of crop development.

Scouting routinely for early symptoms is important to ensure targeted fungicides are applied starting at the onset of disease development. While the forecast program has accurately predicted many outbreaks, a forecasted risk of infection may not result in infection if conditions are not as favorable as predicted, and the forecast program can miss predicting a risk in particular when downy mildew is not reported. The program is predicting movement of the pathogen from known sources of the disease. Photographs of symptoms are posted at: http://blogs.cornell.edu/livegpath/gallery/cucurbits/

4) Apply targeted fungicides weekly with protectant fungicides and alternate among available chemistry based on FRAC code to manage resistance development and avoid control failure if resistance occurs, and also to comply with label use restrictions on number of consecutive and total applications allowed. Start with protectant fungicides alone when there is a low risk of downy mildew for the specific crop based on the forecasting program. Chlorothalonil and mancozeb are the main conventional protectant fungicides for downy mildew; copper is not as effective. Include targeted fungicides when downy mildew is present in your area and forecast risk is high. Add new fungicides to the program when they become available; substitute new for older product if they are in the same FRAC group. Most fungicides labeled for downy mildew are also labeled for Phytophthora blight, which is caused by a related (oomycete) pathogen. See table at https://www.vegetables.cornell.edu/pest-management/disease-factsheets/downy-mildew-of-cucurbits/.

Orondis (FRAC Code 49). The novel active ingredient, oxathiapiprolin, has exhibited excellent activity in fungicide evaluations. It is formulated with mandipropamid (FRAC 40) as Orondis Ultra (REI is 4 hr) and with chlorothalonil (M5) as Orondis Opti (REI is 12 hr). PHI is 0 day. Make no more than 2 consecutive applications of either before rotating to a different fungicide. When at least 3 applications for downy mildew will be made, Orondis fungicides can be no more than 33% of the applications, or a maximum of 4 applications per planting, whichever is fewer. Orondis Opti is labeled for several other diseases because it contains chlorothalonil. It is only recommended used for these diseases when downy mildew is also present. Orondis Ultra is also labeled for Phytophthora blight. Another fungicide, Orondis Gold, is only labeled for application to soil for Phytophthora blight. Its use in a crop prohibits foliar application of Orondis fungicides for downy mildew.

Omega (29). REI is 12 hr. PHI is 7 days for squash/cucumber subgroup, which includes pumpkin, and 30 days for melons. Apply no more than 7.5 pts/A to a crop or 4 applications applied at highest label rate of 1.5 pts/A. Omega is more expensive than other fungicides.

Ranman (21). Use organosilicone surfactant when water volumes are less than 60 gallons per acre. REI is 12 hr. PHI is 0 day. Apply no more than 6 times in a season with no more than 3 consecutive applications.

Zampro (40 + 45). Apply no more than 3 times in a season with no more than 2 consecutive applications before switching to a fungicide with different FRAC code. REI is 12 hr. PHI is 0 day.

Zing! or Gavel or Elumin (22). Zing! and Gavel are the only products that consist of a targeted fungicide and a protectant fungicide (chlorothalonil or mancozeb). REI is 12 hr and PHI is 0 days for Zing!. REI is 48 hr and PHI is 5 days for Gavel. Apply no more than 8 times in a season. Some cantaloupe varieties are sensitive to Gavel (see label). Workers must be notified that a dermal sensitizer is applied both orally and by posting at entrance to treated area 24 hours before the scheduled application and for 4 days afterwards. The amount of chlorothalonil in Zing! is an intermediate rate (1.18 lb/A chlorothalonil) of the labeled rate range for downy mildew in products with just chlorothalonil (1.125-1.5 lb/A). Chlorothalonil is labeled for use at a higher rate (1.5-2.25) to manage several other diseases including powdery mildew. Growers trying to manage these diseases as well as downy mildew should apply additional Bravo to bring the amount of chlorothalonil up to the higher rate. To obtain an application rate of 1.5-2.25 lb/A chlorothalonil, tank mix Bravo WeatherStik at 0.43-1.43 pt/A with Zing!.

Ariston, Curzate or Tanos (27). These have some curative activity (up to 2 days under cool temperatures) but limited residual activity (about 3-5 days). They can be a good choice when it was not possible to apply fungicide at the start of a high risk period when temperature is below 80 F. Apply another targeted fungicide 3-5 days later. Both must be tank-mixed with a protectant. REI is 12 hr. PHI is 3 days. Apply no more than 4 times in a season (6-9 for Curzate depending on rate); no consecutive applications of Tanos are permitted. Tanos also has a FRAC Code 11 ingredient. It is recommended used only when this ingredient is needed for other diseases that are also occurring, such as Plectosporium blight. Tanos is the only one labeled for Phytophthora blight.

Previcur Flex (FRAC Code 28). Only labeled for downy mildew. REI is 12 hr. PHI is 2 day.

Targeted fungicides recommended used sparingly to crops other than cucumber or for Phytophthora blight when downy mildew is not present.

Presidio (43). Recommended used early in the season for Phytophthora blight when downy mildew is not a concern. Apply no more than 4 times in a season with no more than 2 consecutive applications. Must be applied with another fungicide.

Revus and Forum (40). Revus can be applied up to 4 times with no consecutive applications and Forum 5 times with at most 2 consecutive applications. REI is 12 hr and PHI is 0 day for both products. There is a different FRAC code 40 fungicide ingredient in Forum and Revus which may have slightly different mode of action, thus there may be benefit to using both in a fungicide program. Both must be applied as a tank mix with another non-Code 40 fungicide. A spreading/penetrating type adjuvant must be applied with Revus and is recommended for Forum.

Fungicides with mefenoxam and metalaxyl (FRAC 4), e.g. Ridomil, or a strobilurin active ingredient (FRAC 11), e.g. Cabrio, have not been recommended since 2004 as they have been ineffective due to resistance.

Fungicides for organic production. Copper and several biopesticides are labeled for downy mildew and other cucurbit diseases. Due to their contact activity they are not as effective as targeted fungicides, and thus are recommended applied at least once a week on a preventive schedule. Implementing an integrated program with resistant varieties is more important than with a conventionally produced crop. A list of biopesticides is at the webpage below.

Additional information is at https://www.vegetables.cornell.edu/pest-management/disease-factsheets/downy-mildew-of-cucurbits/

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended. Confirm state registration before purchase.

Acknowledgement: Some research reported here was funded by USDA Agricultural Marketing Service Specialty Crop Multi-State Program.

CUCURBIT VARIETY SELECTION

Jay Ruwet, Gowan Seed Company

In finding the right variety that fits your growing operation, three factors will come into play when selecting the right one. 1) Marketable yield. Without a good yield and one that can be marketed to a growers customer base, it is not really worth moving forward with a variety. Especially with the rising production costs. We have seen numerous varieties come forward with excellent quality but producing poor yields, which then negatively impact a grower's bottom line. Therefore making sure that a variety can not only produce high yields but ones that will be marketable is very important in variety selection 2) Disease resistance. Selecting a variety that has some sort of resistance/ tolerance to disease and/ or virus is a major factor in moving a variety forward. In the case of cucurbits we look for tolerance/ resistances to Powdery Mildew, Fusarium, Downy Mildew, Cucumber Mosaic Virus, Zucchini Yellow Mosaic Virus, Watermelon Mosaic Virus, etc. 3) Plant Type. Having a certain plant type or structure is crucial in variety selection. Looking to see if a variety has good vigor and plant health is #1. Will this variety have a strong enough plant health to endure through stressful conditions such as wet and drought conditions? From there we look at the plant structure to see if the plant will provide enough coverage to prevent sunscald and at the same time will it be an open enough plant for harvest ease.

These are just a few of the many factors we take into consideration when selecting a variety in our trials to move forward with to commercial availability. As a dealer we work with many suppliers, all in which have their different techniques and strengths in breeding. Below we will touch on some of these cucurbit breeding programs and their varieties.

Enza Zaden

Enza Zaden's cucurbit program has been excelling in recent years in watermelons and zucchini summer squash. Their current commercial zucchini program consists of varieties such as Cash Machine, Green Machine and Dunja, just to name a few. These varieties have been commercially available for some years now and have good success in the market from the Southeast up into the Northeast. Both Cash Machine and Green Machine will have medium green fruit and nice open plant types for harvest ease. Both produce good marketable yields on the later sets. Dunja, produces a dark green fruit with minimal to no flecking. It has been a few years since Enza has come out with a new green zucchini variety but they have been working on some new material in recent years, of which we have been trialing and have seen some great advancements in fruit quality as well as good crown sets and late sets being produced.

Enzas watermelon program has made some great strides as well, focusing on breeding for deeper red interior, eating quality and darker rind color appearance. The variety Red Garnet have been doing well in the 45 bin count class with some of the strongest plant health and vigor. It also produces a dark crimson color rind for good eye appeal and a deep red interior. Other varieties like Red Amber and Red Opal, while lighter colored rind, have been proven commercial varieties up and down the east coast. Looking down Enza's watermelon pipeline there will be more to come in adding on to the watermelon lineup.

Syngenta

Both in Watermelons and Summer Squash Syngenta has had a dominate breeding program in both crops for a number of years. In yellow straight neck summer squash they have produced a leading line up with varieties such as, Fortune, Goldprize and Grandprize. For years these 3 varieties have been standards with their high disease and virus tolerance, which aided for their strong plant type to produce high marketable yields through adverse conditions.

In Zucchini, Syngenta has produced varieties with very good disease and virus tolerance with varieties like Payload and Paycheck. While improving on harvest ease and minimizing fruit scaring with spineless varieties Spineless Perfection and Spineless Supreme.

The Syngenta seedless watermelon program has also been a dominate force starting out with the mini personal size seedless watermelons like Sirius. Then moving on to the 12-16# class, Sweet Gem, with high eating quality and an unmistakable dark green rind. As we get into the 45-36 bin count class Captivation, Fascination, Exclamation and Excursion have become main stays from early to late season maturity. Fascination, in fact, set a new standard for the darker crimson rind color that set a new standard for that darker rind patterned that created more eye appeal for consumers on the shelves.

Sakata

Watermelon program has brought on some new material in the past 2 years and we have seen some great improvement with their new varieties. Last season was the first time we have looked at their new material and it looks very promising in the 36-45 bin count class. On top of that Sakata has 2 of the best pollinizers on the market Ace Plus and Wild Card Plus. Both varieties produce an abundant amount of male flowers and for and for an extended period of time, creating a longer window of pollination.

While Sakata has not traditionally focused on zucchini breeding they have recently come out with a new variety called Endeavor. This variety is a medium to dark green variety with intermediate powdery mildew resistance and some virus resistance. The most interesting characteristic with this variety is that it has a very open plant that makes it very easy to harvest fruit.

Seneca Vegetable Research

Seneca Vegetable Research produces one of the only truly spineless yellow straight neck summer squashes called Smooth Criminal. Having Smooth Criminal as a true spineless variety, decreases scaring on the fruit therefore increasing its higher quality marketable yield. Although there are no claims to disease resistance for Smooth Criminal, it has shown great field tolerance, producing high yields. SVR's pipeline in coming forward with new spineless varieties is looking strong and with improved disease tolerance.

Tokita

Tokita, is a breeding company that has been around for many years but is fairly new to us on the east coast. We have been looking at their cucumber material for about 4 years and were initially impressed with their disease resistance compared to the standard commercial varieties. Varieties like 203 from Tokita have been doing very well in the field holding up to diseases like Downy Mildew and producing good quality fruit. While their yields and fruit quality are good, they can be improved upon. We have been working closer with Tokita and will be doing more trials this season with new experimental varieties that show that same disease tolerance while increasing marketable yields.

All in all, it is not just one breeding company that will work for your farming operation, it is a mix of them all. Each one has their own strengths for certain situations, whether it is disease resistance, optimal yields, plant types or performance under stress. The key is selecting the right varieties that work well for your operation and just because one variety may work for your neighbor does not mean that it will work for you. It will always be the case of trial and error, which is why we continue to trial varieties each year across many different regions along the east coast and with many different growers.

COMMON CHALLENGES IN PRODUCING SPECIALTY PEPPERS

Lenny Burger III, Burgers Farm

COMMON CHALLENGES IN PRODUCING SPECIALTY PEPPERS

- Planting
- Growing
- Harvest/Marketing

1

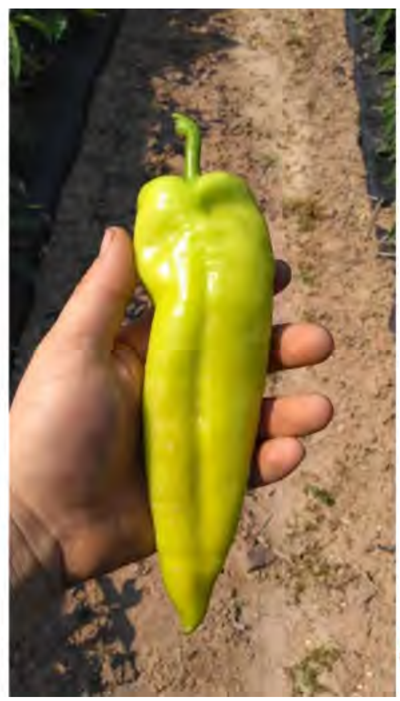
PLANTING

- Finding varieties and a consistent supply of seed to satisfy the customers
- Planting ample supply of plants (more than needed for production) i.e. trying to find replacement specialty plants at planting time tends to be very difficult
- Finding planting dates to provide adequate production at time of demand

2

GROWING

- Weed control is similar to regular pepper production but some specialty varieties are more susceptible to herbicide damage, so it needs to be monitored on a variety-to-variety basis
- Disease control is also something that tends to be more difficult than regular pepper and eggplant production
  - The varieties sometimes tend to be more susceptible to common disease than more commercial grown varieties
  - More attention is needed in scouting and early disease detection
- Some specialty varieties don't produce as much as modern hybrids



HARVESTING

- Harvest timing
  - Having the crop ready when the customer demand is at its peak
- Understanding harvesting techniques
  - For some crops the first harvest matures in the center of the plant making it more susceptible to breaking the plant

4

MARKETING

- Adjusting to specialty crop customers
  - A lot of times specialty crops are associated with ethnic diverse customers that are not always local to your area
  - Finding ways to make them comfortable while shopping at your market
  - Welcoming atmosphere. i.e. language barriers
- Shopping by weight/volume

PEPPER PIPELINE UPDATE AT SEMINIS

Marie Bourguignon
Seminis – Bayer Vegetable Seeds Division, 338 Jefferson Avenue, Downingtown, PA 19335,
marie.bourguignon@bayer.com

Building its reputation with reliable products such as Aristotle, PS 09941819, Archimedes, SV3964PB, and Turnpike, Seminis® (now part of Bayer Vegetable Seeds Division) was the first to deliver high-quality peppers that harness the full potential of X10R®.

Discovered through traditional plant breeding efforts, X10R® was developed through screening thousands of parental lines and hybrids. In 2016, Seminis® released Playmaker, the only bell pepper on the prior market with resistance to both all races of Bacterial leaf spot (XR) and Phytophthora blight, which is a devastating disease in the Mid-Atlantic. Since then, the pepper breeders have been actively working on offering our growers a comprehensive defense against both diseases, while providing high fruit quality, uniformity, and set. Tarpon is the newest green blocky, while Sailfish is more adaptable to the open field red market. But Seminis® does not stop here. The specialty pepper market such as mini-pointed, jalapeno, etc. is also being improved with new X10R® varieties.

Feel free to stop by to hear more about the innovations at Seminis®, where to buy these pepper products, and ask your questions!

Marie Bourguignon has been working at Seminis – Bayer Vegetable Seeds Division for four years as their Market Development Representative III for the Mid-Atlantic. More specifically, Marie is part of the Product Development Team and has been working closely with growers and R&D to trial, understand, and select the best varieties for the region and bring them to the commercial phase. Marie was previously employed at the Monsanto Learning Center in Scott, MS where she was responsible for the setup, management, and maintenance of various research projects involving corn, soybean, and cotton. Marie earned her MS in Plant and Soil Sciences at the University of Kentucky and her PhD in Crop Production and Physiology at Iowa State University.
Originally from France, Marie has fully immersed herself in the American culture and life for 10 years and is not ready to leave just yet. She recently got engaged to her partner in crime Caleb who is working far from the Ag world. They both live in Downingtown, PA.

ASPARAGUS VARIETIES FOR COMMERCIAL PRODUCTION

Scott D. Walker
Walker Brothers, Inc., 105 Porchtown Road, Pittsgrove, New Jersey 08318

Climate change is real and has become an inevitable challenge for the asparagus industry. Asparagus growers are forced to face the more frequent extreme weather conditions. It's likely that global warming will lead to a change of current asparagus varieties in regions with temperate climates, including northern America, western and northern Europe. Being the world's leading green asparagus seed production and breeding company, our primary goals are to keep searching suitable homes for our current commercial asparagus varieties, to develop new hybrids that can counter the current climate change and help asparagus growers be successful in a very competitive industry.

Suitable homes for current commercial varieties

The warm-climate green asparagus varieties, such as Atlas F1™, Grande F1™, and UC 157 F1, continue to do well in tropical and subtropical countries. As the weather around the world becomes more extreme, these varieties are also becoming more desirable for growers in temperate climate regions. Due to climate change, those growers have to look for alternative varieties that can adapt to warmer and drier weather during harvest. Also, when growers want to grow asparagus for early production, they usually search for varieties that need fewer growing degree days (GDD) to emerge. For example, growers in Kanagawa, Japan, like UC 157 F1 due to its relatively early emergence in the open fields in spring. The GDD of this variety was 79 when the spears started to emerge. Compared to this, some varieties would need 190 GDD to see spear emergence. The difference in the dates when the first spears appear can be up to 2 weeks.

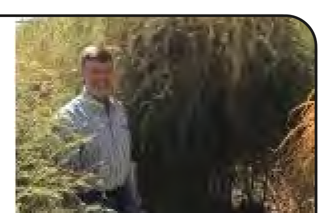
Major characteristics for new varieties

Asparagus varieties suitable for temperate climates are more likely to produce open-head spears when the temperature is exceptionally high during harvest. Hence, asparagus tip tightness is of top importance when developing new varieties. With the extended drier or wetter days in the growing season, breeding a variety with good resistance to foliage and root diseases, like Fusarium, is vital for the success of asparagus production. Increasing labor cost and worker shortage also reminds breeders to develop varieties with more uniform spears. Last but yet importantly, we draw special attention to early variety development. Growers who have asparagus production in high tunnels or in warmer regions keep looking for varieties with early production to boost their sales and income.

International trials for new varieties from the Walker Breeding Program

Typically, it takes 5 to 10 years to develop and commercialize a new asparagus variety. We have selected some promising candidates after a six-year yield evaluation of new hybrids at our farm in New Jersey from 2010 to 2015. We propagated the parental plants of the promising hybrids and produced seed from 2018. The cooperation with universities, private farms and seed companies worldwide commenced in 2020. So far, we have established new asparagus trials in 17 countries. The early data from the trials in Asia is very encouraging, especially when spears of the new hybrids were harvested at a length of 15 inches at 85F. We believe that as long as any new hybrids can grow and yield well in stressed conditions, they will also stand out and counter the global warming challenge.

Scott D Walker is the president and the fifth-generation owner of Walker Brothers Inc, in Pittsgrove, New Jersey. He has been involved in asparagus since 1972 and has unfathomable asparagus knowledge. His daily role is a Sales and Marketing Manager. He also involves in the Walker Breeding Program, including trial establishment and yield evaluation of new hybrids. He participated in almost all International Asparagus Symposium held every four years in different countries to meet with growers and researchers.



ASPARAGUS CARBOHYDRATES AND HIGH TUNNEL PRODUCTION OR HIGH YIELDS

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Asparagus prefers temperate climates when diurnal temperatures do not change greatly. Soil temperatures above 40°F trigger bud break and spear elongation in spring. Once the spear emerges from the soil, continued spear growth is controlled by air temperature. Asparagus spears are cold (32-40°F) tolerant but are frost (<32°F) sensitive. Cold weather and frost regularly delays productivity. After harvest, optimal fern growth occurs when temperatures range from 60-85°F. High and low tunnels increase both earliness and total productivity for many vegetables, small fruits and flowers. Careful temperature manipulation is needed however to ensure spear quality is maintained in enclosed tunnel structures. At temperatures above 80°F, spears branch early which downgrades quality and marketability. Very few studies have looked at tunnel production in asparagus. Utah State University has studied high tunnel production for a variety of crops. Growing annual asparagus and improving existing field production with tunnels can enhance early harvest and improve yields.

The size of the root system and its distribution in the soil affects the ability of asparagus to store nutrients and carbohydrates, which determines crop health and productivity. Asparagus is a perennial crop with crop maturity and economic production typically occurring between years 4-8 of a 10-15-year production cycle. Farm management decisions this year determine the next years' crop performance. Fibrous roots facilitate water and nutrient uptake, while the larger fleshy roots are essential for storage of carbohydrates (CHO's) and nutrients that lead to productive spear growth. CHO rich roots are the 'Engine' which controls yield, drives stand longevity, and creates economic profitability (Fig. 1). Farm profitability may necessitate strategy changes to asparagus production. High tunnels, high plant densities, and alternative production approaches may allow farms to produce "annual" asparagus and move away from growing asparagus as a perennial. This presentation will discuss alternative production strategies for asparagus.

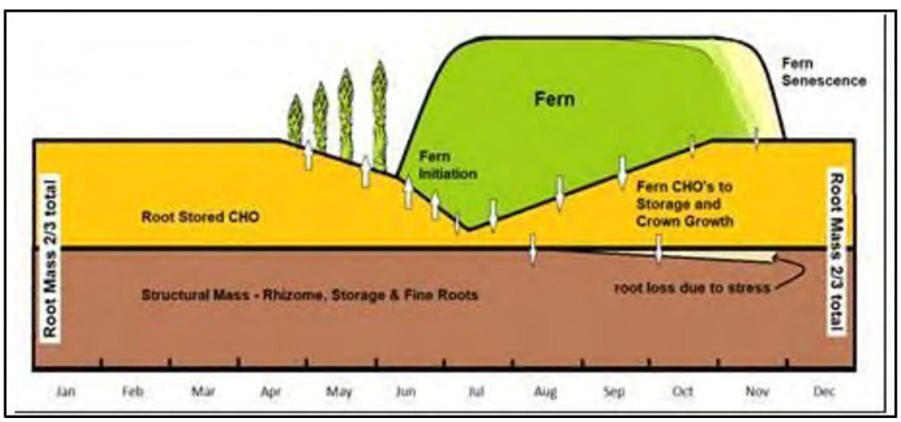
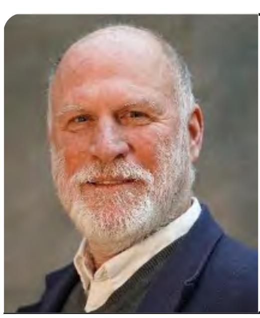


Fig. 1. Seasonal pattern of spear, fern, and root biomass accumulation in mature asparagus. Arrows indicate direction and amount of carbohydrate (CHO) movement from roots to spears/fern (spring/summer) and from fern to roots (summer/autumn).



Dr. Daniel Drost is a Professor of Horticulture and Extension Vegetable Specialist in the Department of Plants, Soils and Climate. Dr. Drost grew up on a diverse crop-livestock farm in western Michigan and has graduate degrees from Michigan State and Cornell University. His extension program focuses on sustainable vegetable production systems and improving productivity by the use of new and novel technologies. His research focuses nutrient and water management, farming systems research, how to improve plant performance in organic and conventional systems, and growth optimization in highly managed environments.

Regular frost events in early spring are common and can severely limit early marketing potential for asparagus and often delay spear re-emergence. Early spears are the largest spears and are valued in local markets. Delays in production limits the length of the harvest season as most farms terminate harvest by early June. This allows plants time to recover, recharge the root system, and replace the buds that will be the next season's harvest (Fig. 1). Using high or low tunnels in asparagus systems may mitigate the effects of early frost, provide early yields for local markets, and extend the annual production to where it is more profitable for the grower. These approaches are quite common in European systems.

Asparagus harvest commonly starts in year three (1-2 week harvest), which allows the plants time to grow roots, store CHO's and produce sufficient buds. After five years, spears are harvested for 8-10 weeks if plants are healthy. Since perennial crops like asparagus come into full production slowly, this adds cost to the producer. Work in Japan demonstrated that annual asparagus was feasible and productive. Their system used existing plant populations (10-12,000 plants/A), was very early relative to field production, and was financially viable for the grower. Transplants were used (cheaper) but root size was still small after one year of growth and bud numbers are limited. Takatori (in California) showed that at higher plant populations (20-25,000 crowns/A), early yields increased by 30-40% but spear size was smaller than desired. Our early work with annual asparagus in high tunnels caused spears to emerge in mid-March. As plant population increased from 58,000 to 116,000 plants/acre, medium spear numbers decreased while small and very small numbers increased (Table 1). Given this information, we are now comparing transplants (12-weeks old) to 1-yr-old crowns (field grown) at different densities to identify systems that produce more and bigger spears. Do increasing plant populations and associated spear production offset the higher input costs of transplants or crowns? While initial findings show promise, it is still too early to recommend changing to excessively high plant populations but earlier asparagus grown in high tunnels looks very productive.

Table1. Asparagus production in an annual, transplant high tunnel system (2019-2020)

Plant Spacing	Plants/acre	Spear Production (#/acre)			
		Medium	Small	Marketable	Very Sm & Cull
3" x 18"	116,160	44,677	547,292	591,969	1,452,000
4" x 18"	87,120	55,846	513,785	569,631	1,442,257
6" x 18"	58,080	78,185	435,600	513,785	1,407,324
	sign. 0.05	L*	L*	L*	L*

- 22 Harvests; March 11 to April 11, 2020 (preliminary findings)

INSECTICIDE PROGRAMS FOR MANAGEMENT OF ONION THRIPS

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Onion thrips are one of the most economically important pests of onion nearly everywhere that onions are grown. The tiny, slender adults and larvae feed on onion leaves, starting from the neck and moving outward to leaves as population density increases. Their feeding removes chlorophyll, reducing the plant's ability to photosynthesize and eventually decreasing bulb size. In addition to direct feeding damage, they can also worsen several plant pathogens, making their management a crucial part of onion production. At high densities, they can reduce onion yield by up to 60%.

Figure 1. Thrips larvae are slender and yellow in appearance, typically clustered near the onion neck (L). Damage will appear as whitening of the leaves as chlorophyll is removed (R).

Adult thrips lay eggs embedded in onion leaf tissue, where they hatch and complete three larval instars before moving down to pupate in soil nearby plants. After completing pupation and emerging as adults, thrips will move back up the plant to feed, reproduce, and lay eggs. Although both adults and larvae feed on leaves, larvae contribute most to damage and yield losses. The entire life cycle can take 30 days or less and they tend to have 5-8 generations per year in Pennsylvania (more in warmer regions). They overwinter in alfalfa, small grains, and weedy vegetation near field edges and tend to be most abundant after dry, mild winters and hot, dry springs.

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One of the best cultural tactics for managing them is to avoid planting onions downwind from sources of infestation, such as alfalfa or small grains. If you must plant near these crops, consider keeping an eye on onions as alfalfa is cut or small grains are harvested. To decrease susceptibility to thrips feeding, keep onion plants adequately fertilized and watered to increase plant vigor. The movement of thrips from plant to soil for pupating and back to plant can be targeted through adding straw mulch to onion beds if onions are direct-seeded. This works through inhibiting movement, as well as fostering beneficial predators that may feed on thrips. However, plastic mulch does not have this effect and straw tends not to be as economically feasible as scale of production increases. There has been limited success with planting resistant or semi-resistant varieties.

There are reliable action-thresholds to inform insecticide application decisions. It is recommended to spray when densities reach 1 thrips per leaf, in order to maintain populations below a level where economic losses would occur, around 2.2 thrips per leaf over the season. To calculate whether thrips densities have reached the action threshold, inspect plants for thrips being careful to thoroughly check the inner neck of the onion, as well as the outer surfaces of leaves as populations increase. Next, count the number of green leaves on the onion (do not count leaves that have already senesced) and divide the number of thrips found by the number of leaves to get the number of thrips per leaf. Because thrips have many overlapping generations each season, resistance can develop when insecticides are applied repeatedly. A best practice for thrips management is to rotate active ingredients every two weeks throughout the season to avoid repeated exposure of a generation to the same ingredient.

For organic onions, insecticide options include Entrust, Azera, Pyganic, and Surround. Entrust has been the most effective, through it should still be rotated every two weeks to preserve efficacy and reduce the risk of developing resistance. The most current insecticide recommendations for conventional management of onion thrips in the Northeast are updated by Cornell Cooperative Extension annually and can be found on their website. Once the action threshold is reached, Cornell's recommended sequences begin with either Movento or Senstar prior to onion bulbing to get the most benefit from these products system activity. Other effective products include AgriMek SC, Exirel, Radiant, Minecto Pro (a pre-mixture of the active ingredients in AgriMek and Exirel), or a tank mixture of Lannate and Warrior. Be sure to follow each product's label to avoid overapplication within a season and rotate between active ingredients every two weeks. If you need assistance accessing these recommendations, reach out to me using the contact information above.

IDENTIFICATION AND MANAGEMENT OF COMMON FOLIAR (AND BULB) DISEASES OF ONION

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Although there are over fifty diseases of onion and garlic worldwide, there are only a few diseases that are common in Pennsylvania and the mid-Atlantic region. These include the fungal diseases purple blotch, Stemphylium leaf blight as well as Botrytis neck rot and black mold and to a lesser degree Botrytis leaf blight. There are also several bacterial diseases including center rot, sour rot, and slippery skin that can affect the leaves and/or bulbs.

Stemphylium leaf blight (pictured right) is becoming increasingly problematic and is now considered the most significant foliar disease of onion in New York and Ontario, Canada. The lesions are initially small and water-soaked before turning yellow to tan in color. As they enlarge, they become elongated and develop dark brown to black spores on the surface and a black residue will be left on your fingers when you run it across the lesion. It can also cause a tip dieback that can progress down the leaf. The disease favors damaged or diseased leaf tissue and can often follow diseases such as purple blotch. It is also more common on plants damaged in the drive rows, by hail/strong storms, herbicide injury or are stressed. Disease development is favored by warm, wet weather. The pathogen can also affect tomato, carrot, asparagus as well as several other hosts however, the ability to cause disease on different crops depends on the genetics of that particular pathogen population. Transplants could be a source of the pathogen however, it is more likely overwintering in crop residue, surviving associated with volunteer onions or asymptomatic weed hosts such as yellow nutsedge, field pennycress, and red root pigweed.

Purple blotch (pictured right) is caused by *Alternaria porri* and is specific to plants in the Allium family. It causes small water-soaked lesions that become zonate and brown to purple in color as they enlarge. The lesions can grow together or coalesce and cause a blighting down of the leaves. The leaves become more susceptible as they age, and disease development is favored by warm, wet weather. Compared to Stemphylium leaf blight, purple blotch can more readily develop on healthy green leaf tissue. Similar to other Alternaria leaf blight diseases, the pathogen survives between seasons in crop residue and in cull piles.

Management of Stemphylium leaf blight and purple blotch includes a three- to four-year crop rotation to allow the crop residue to decompose, optimizing crop nutrition to reduce plant stress, weed management in and around fields, and use of fungicides under high disease pressure. In New York and Ontario, Canada Stemphylium leaf blight resistance to fungicides in

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FRAC groups 2, 7, 9 and 11 has been reported causing a reliance on fungicides in FRAC group 3. Resistance has not been reported in PA however, it is important to rotate among FRAC groups to reduce the potential development of resistance. To-date, biopesticides have provided limited efficacy against these diseases.

Botrytis leaf blight and Botrytis neck rot are caused different species of Botrytis that are specific to onion. Botrytis leaf blight is caused by *Botrytis squamosa* while Botrytis neck rot is most often caused by *Botrytis alli*. Lesions caused by Botrytis leaf blight are whitish and surrounded by a greenish-white halo. The whitish appearance is due to the degradation of tissue under the leaf surface by enzymes produced by the pathogen. The lesions become tan in color and eventually blight down the leaf. Grayish sporulation will develop on the surface of the dying tissue similar to other Botrytis diseases such as grey mold on tomato or strawberry. The optimum temperature for disease development is between 64 and 68°F with leaf wetness so it is a cooler weather disease.

Symptoms of **Botrytis neck rot** (pictured right) typically develop postharvest in storage although initial infection occurred in the field. The neck and shoulder of the onion become soft and water-soaked and gray sporulation can be seen when peeling back the papery layers and scales. Over time, the onion scales become brown in color and dark brown sclerotia can develop between the infected scales. In contrast to black mold (described next), Botrytis neck rot is problematic when it is cool and wet. Infection by the pathogen occurs in the field and if the necks are not properly dried down then there is a risk of disease development in storage. Field curing can help reduce potential losses. Both species of Botrytis overwinter as sclerotia that are produced as the plant tissue dies and then fall to the soil where they can germinate and be a source of the pathogen the next season. Onion cull piles can also be a source of the pathogen. Field curing before topping can help reduce losses, avoid harvesting in wet weather, and avoid over fertilizing with nitrogen during the season.

Black mold is the superficial black soot-like fungal growth on and between bulb scales that is caused by Aspergillus niger (Photo credit Tom Butzler, Penn State Extension). The fungal pathogen is commonly found in the soil and on crop residue and affects many vegetable crops. It is primarily a post-harvest issue when the bulbs remain hot under high relative humidity (>80%) or there are fluctuations in temperature (e.g., coming out of storage) that result in the formation of condensation on the bulbs while in bins and then exposure to high temperatures. Reducing exposure to high temperatures and storing in low humidity will help manage black mold.

Bacterial diseases of onion continue to be a challenge to manage in Pennsylvania. The past two years, a survey was conducted in five PA fields each year where ten onion plants with suspected bacterial disease symptoms were collected at two time points during the growing season. A systematic approach was used to isolate and identify bacteria from the symptomatic leaf and/or bulb tissue as a part of a national USDA NIFA Specialty Crop Research Initiative project titled 'Stop the Rot' led by Washington State University (2019-51181-30013) which was initiated in 2020 and continues to build off projects funded by PVGA/PVMRP over the years. The bacterial isolates obtained were also tested to determine if they could cause disease using a red onion scale assay. Each bacterial isolate was inoculated into the red scale of an onion and if a zone of clearing develops (the red color becomes clear) then it is considered pathogenic. Similar to the human body, not all microbes isolated plants are pathogens so being able to differentiate them is important. In 2020, a total of 654 bacterial isolates were obtained from 20 symptomatic plants and approximately half were identified to bacterial genus. Of those isolates, 44% (n=152) were identified as *Burkholderia* or *Pantoea*, both known pathogens of onion. Of the *Pantoea* isolates, 52% were determined to be pathogenic using the red scale assay and were isolated primarily from the leaves of plants collected from four of the five fields during the first sampling in June. In contrast, 81% of the *Burkholderia* isolates were determined to be pathogenic and were isolated from all five fields primarily during the second sampling in July right before harvest and were isolated equally from leaf and bulb tissue. So earlier in the season, *Pantoea* spp. are causing foliar symptoms but later in the season it is easier to isolate pathogenic *Burkholderia* spp. from the symptomatic bulb tissue and the majority of the *Burkholderia* isolates recovered are pathogenic on onion.

Pantoea spp. are known to cause the bacterial disease center rot.

Center rot (pictured right) is characterized by a single rotting scale within the bulb that results from the bacteria moving down a symptomatic interior leaf into the neck and then bulb. Initially foliar lesions are small and water-soaked before turning light tan in color and as the disease progresses individual leaves become bleached as the bacteria progresses towards the bulb. The pathogens can be associated with the seed and transplants as well as survive on weeds in the field. Disease development is favored by warm, wet conditions and readily spreads in rain splash. Reducing soil temperatures at bulbing has reduced losses as has reducing total nitrogen and limiting nitrogen applications to pre-bulbing when the plants are actively growing leaves. Field curing and thoroughly drying the onion necks will stop the progression of the bacteria from the leaves into the bulb. Management with the application of in-season products has been highly variable although trials are on-going to identify products that could be included in an IPM program.

Burkholderia spp. are soilborne and known to cause the bulb diseases sour skin and slippery skin. **Sour skin** is characterized by a rotting of the outer scales and has a very foul vinegar odor as a result of colonization by secondary organisms. The affected scales will turn reddish-brown to brown in color and become very liquid in consistency. **Slippery skin** is more similar to center rot in that the outer scales remain intact but multiple inner scales can be affected turning brown and watery. The disease is called slippery skin because the center of the onion will slip out when pressure is applied to the lower portion of the onion bulb. Both diseases are favored by warm and wet weather especially later in the season. Management is challenging because the bacteria are soilborne and can survive in the absence of a plant host. An integrated approach as recommended for center rot is also recommended for slippery and sour skin.

CAN DUAL MAGNUM BE APPLIED OVER PUMPKIN VINES?

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Weed control in pumpkins is challenging for many reasons, including the production practices of wide rows, no-till (which excludes use of cultivation), a long growing season and limited number of herbicide options. These practices result in a greater reliance upon herbicides for weed control. Unfortunately, there are very few herbicides labeled for postemergence weed control in pumpkin, and even fewer are available to control herbicide-resistant species such as Palmer amaranth and waterhemp. Therefore, novel uses of soil-applied herbicides need to be explored. One approach to improve overall weed control is to apply a second residual herbicide over the top of the emerged crop, but before the weeds have begun to emerge. This approach is referred to as overlapping residuals.

Dual Magnum is a common residual herbicide labeled for numerous crops, but not labeled preemergence in pumpkins. The current Dual Magnum label stipulates the following: "Apply as an inter-row or inter-hill application. Leave 1 foot of untreated area over the row, or 6 inches to each side of the planted hill and/or any emerged pumpkin foliage (inter-row or inter-hill means not directly over the planted seed or young pumpkin plants)." However, recent greenhouse and field studies have demonstrated good crop safety when using Dual Magnum over-the-top of pumpkin vines as an overlapping residual treatment. Dual Magnum will not control emerged weeds but weed control efficacy may be extended if it is applied sequentially, before the first herbicide dissipates. Dual Magnum provides residual control of several key annual small-seeded broadleaf and grassy weeds. Furthermore, weeds like Palmer amaranth and waterhemp are extremely aggressive and are spreading rapidly around the region and are on the PA Noxious Weed List. However, not many pumpkin herbicides are that effective on these noxious pigweeds. Here are some general comments:

- Command is not effective on these pigweeds
- Sandea has activity but does not control ALS-resistant (group 2) Palmer amaranth and it may cause stunting of the pumpkins
- Curbit will provide control, but its length of control is short
- Dual has activity but it cannot be used over the planted row currently. A sequential application made about 3 to 4 weeks after planting should provide adequate control of later emerging pigweeds allowing for cleaner fields at harvest.
- Shielded applications of Aim can control it but growers may not be willing to use this tactic
- Cereal rye can help suppress the weeds but then cultivation is no longer an option
- Choose the right field....don't plant where these noxious pigweeds have established

It is best to use an integrated weed management approach that includes some of the following: appropriate herbicides, crop rotation, hand-weeding, post-harvest control, cover crops, cultivation/tillage, and decreased row widths.

Over the past couple years, nationwide field studies have been conducted, including here in Pennsylvania and the Mid-Atlantic region, on the utility of Dual Mangum applied postemergence to pumpkins. Thus far, the results look promising to potentially obtain a label for this use.

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

MANAGING POWDERY MILDEW AND BACTERIAL DISEASES ON PUMPKINS

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Managing Bacterial Diseases. Angular leaf spot (ALS) and Xanthomonas leaf spot (XLS; previously known as bacterial leaf spot) are 2 diseases of cucurbits caused by bacteria occurring in the northeast. Symptoms are similar and include water-soaked, brown leaf spots often with yellow halo and angular shape delineated by veins. Symptoms also develop on fruit; petioles and stems with ALS. Photographs are posted at https://blogs.cornell.edu/livegpath/gallery/cucurbits/. In the northeast, ALS has occurred less commonly and more sporadically than XLS, and contaminated seed has been a suspected source of ALS pathogen. Both pathogens can survive in infested crop debris.

Purchase seed that has been tested for bacterial pathogens, especially ALS. While both can survive in seed, XLS pathogen has not often been found in commercial seed lots, and when found it was at a low level. It was shown to survive about 2 years in seed (18 mo at 72 F and 28 mo at 39 F), but survival steadily declined over time. There are no resistant pumpkin varieties, only cucumber, but variation in susceptibility has been detected among varieties. Solid Gold was affected less than Charmed in an experiment in OH. When growing transplants, provide separation when possible, such as alternating rows with trays of cucurbits with trays of other vegetables to minimize opportunity for spread. Keep humidity in greenhouse below 80%. Water in the morning when leaves are dry and conditions facilitate fast drying. This is important when growing transplants and also in the field where preferred drip irrigation is not feasible. Avoid planting multiple cucurbit crops together. Check plants routinely for symptoms. Rogueing individual affected plants when detected early is worthwhile, especially when found in trays. Do not work in fields when leaves are wet because equipment and workers brushing against leaves that are infected can move bacteria to healthy leaves touched subsequently. Promptly incorporate crop debris after harvest and rotate fields where cucurbit crops are grown with at least 3 years between cucurbit crops.

Copper combined with mancozeb has been the only fungicide option until recently. It is most effective when applications start before or at very first symptoms. There is concern of bacteria developing resistance to copper. Actigard is labeled for both diseases; plant activators need to be applied starting before infection to be most effective. Labeled biopesticides include Brandt Organics Aleo, Cease and Serenade AOS. Other biopesticides labeled generally for managing bacterial diseases on cucurbits include GreenFurrow BacStop, KeyPlex 350, Thyme Guard, and Thymox Control. Actigard was more effective than Kocide 3000, Serenade Max, and OxiDate in an experiment in OH.

Through research conducted recently in Illinois (M. Babadoost et. al.), a 3-yr rotation was shown effective for delaying onset and reducing severity of XLS compared to a 2-yr rotation or continuous pumpkin production, but did not eliminate XLS. XLS pathogen was able to infect bur cucumber and velvetleaf, and was isolated from some symptom-less weeds. It was shown to remain viable for at least 2 years when associated with plant debris (leaves and fruit), but not to survive in soil long enough for soil to be a potential source of the pathogen. Potential sources of resistance to use in breeding were found. In a fungicide efficacy trial conducted in 2020, best control of both foliar and fruit symptoms was achieved with Regalia alternated with Manzate Pro Stick plus Kocide 3000. Actigard was more effective than Kocide 3000 in an OH experiment.

Bacterial wilt and yellow vine decline are caused by bacteria that invade the xylem and phloem, respectively, causing infected plants to wilt, and are transmitted by insects, cucumber beetles and squash bugs, respectively. Manage these diseases by managing their insect vectors.

Meg McGrath is an Associate Professor with Cornell University located at the Long Island Horticultural Research and Extension Center since 1988. She conducts research and extension activities on optimizing management of diseases affecting vegetable crops and herbs within organic as well as conventional production systems. Research topics include investigating fungicide resistance in the cucurbit powdery and downy mildew pathogens, monitoring occurrence of diseases, and evaluating management practices: fungicides, biopesticides and other organic fungicides, resistant varieties, cultural practices including reduced tillage and mustard biofumigation. Web pages include: http://blogs.cornell.edu/livegpath/ and https://www.vegetables.cornell.edu/pest-management/disease-factsheets/.

Managing Powdery Mildew. A foliar disease like powdery mildew affecting a fruiting crop may not seem as important to manage as one that affects fruit; however, leaves need to remain healthy until fruit matures so they develop full flavor and sugar content for winter squashes. Pumpkin fruit color may not be as deep orange in the absence of powdery mildew control, and their handles usually are not an attractive green due to powdery mildew developing on them and they turn brown, shrivel, and cannot be used to pick up the fruit when their vine dies prematurely because of powdery mildew. Additionally, powdery mildew can increase plant susceptibility to other diseases, notably gummy stem blight (aka black rot).

Grow resistant varieties. They provide useful but variable suppression of powdery mildew from limited in pumpkin and squash to very high in cucumber.

Check upper and lower surfaces of at least 50 older leaves for symptoms weekly beginning at the start of fruit formation, which is a physiological stress that causes plants to become susceptible. Symptoms often appear first on lower surface. Begin applying fungicides as soon as symptoms are seen and continue on a weekly schedule. Conditions typically remain favorable throughout the growing season because powdery mildew develops when it is dry; a prolonged period of rain is unfavorable. Winter is a good time to develop your fungicide program.

Within a week of the last application, look at severity of powdery mildew on leaves, especially the lower surface for crops sprayed with conventional fungicides, to assess degree of control obtained and potential need to change the program for the next year.

The most effective CONVENTIONAL FUNGICIDES are those able to move into leaf tissue and thereby redistribute to the lower surface where powdery mildew develops best. They can do so without affecting the plant because they have single-site mode of action targeted to the pathogen. Unfortunately, this also means these fungicides are at risk for resistance developing in the pathogen and rendering them ineffective. The cucurbit powdery mildew pathogen has proven very adept at developing resistance. Fungicides that were very effective in the past are no longer effective because of resistance. These are Topsin M (FRAC code 1) and QoI fungicides (Cabrio, Flint, Quadris, etc.) (11); almost all pathogen isolates are resistant based on research conducted at LIHREC. Other fungicides providing poor to moderate control, depending on frequency of resistance in the pathogen population in a crop, are Endura (7), Pristine (7), Merivon (7), Quintec (13), and Torino (U6). Isolates of the powdery mildew pathogen have been detected with resistance to multiple fungicides, most notably with resistance to Quintec, Torino, and Endura/Pristine/Merivon. This means applying one of these fungicides can select for resistance to all. When resistance has rendered ineffective one fungicide used in a program applied to a commercial crop, this might not be obvious when the other fungicides used are effective because the reduction in control might not be substantial and thus obvious.

Currently recommended fungicides include Vivando (50), but not Prolivo because it has not exhibited good efficacy in university fungicide evaluations although its active ingredient is in the same FRAC group. While resistance has been detected affecting efficacy of some SDHI fungicides (7) and DMI fungicides (3), others are effective reflecting differences among these fungicides in how they bind to the target site or multiple genes being involved in resistance. Recommended DMI fungicides are Proline (it was the most effective fungicide tested at LIHREC in 2020), Procure, Luna Experience, and Rhyme; Cevya is not as effective. Recommended SDHI fungicides are Aprovia Top (FRAC 3 + 7), Luna Experience (3 + 7), and Miravis Prime (7 + 12). These 3 have a different SDHI active ingredient (AI). The second AI in Miravis Prime (FRAC 12) does not have activity for powdery mildew, in contrast with Aprovia Top and Luna Experience. Gatten (U13) has exhibited variable efficacy; it was moderately effective in a fungicide evaluation in PA in 2021.

Winter is a good time to develop your fungicide program. All targeted fungicides have limits on maximum number of applications and most cannot be applied more than twice consecutively. Fungicide resistance is dynamic. Expect this pathogen to develop resistance to additional fungicides and thus fungicide recommendations to continue to change.

Example recommended targeted fungicide programs (there are other good combinations) (including a contact, protectant fungicide with each application is recommended):

Proline, Vivando, Proline, Vivando, Luna Experience, Vivando (6 applications total). This program has maximum number of applications of Proline and Vivando permitted to a crop.

Proline, Vivando, Proline, Vivando, Procure, Vivando, Procure (7 applications total).

Proline, Vivando, Proline, Vivando, Aprovia Top, Vivando (7 applications total).

Proline, Vivando, Aprovia Top, Proline, Vivando, Luna Experience, Procure, Vivando (8).

Contact fungicides include sulfur, chlorothalonil, mineral oil, and biopesticides (see next paragraph).

There are many ORGANIC FUNGICIDES for powdery mildew. They have contact activity so getting spray deposited on the underside of leaves is important for optimizing control but challenging due to the large size of cucurbit leaves and density of foliage. Sulfur is the most effective fungicide; low rate of a dispersible formulation is recommended. There are several biopesticides labeled for powdery mildew on cucurbits. Using at least two products with different modes of action is a recommended strategy. For information to help with selecting biopesticides see https://www.vegetables.cornell.edu/ipm/diseases/biopesticides/. At this webpage there is a list of biopesticides labeled for use on cucurbits. Search for 'powdery' to see which ones are labeled for powdery mildew. The list includes active ingredient to help with selecting different products. There is an excel spreadsheet with efficacy results from evaluations of biopesticides for diseases of vegetable crops (and basil) conducted at universities and published in PDMR. Results were used to calculate % control. If you download the file to look for results, best to hide columns H – U as most important information is whether treatment was effective and % control achieved which are in columns V – Y. There are 2 tables with summary results from solo product evaluations in the database. These are also at the webpage.

There is additional information about this disease and its management at https://www.vegetables .cornell.edu/pest-management/disease-factsheets/cucurbit-powdery-mildew/

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.

THE STATUS AND STRESSORS OF SQUASH BEES IN PENNSYLVANIA

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Project goal: In the United States, squash, pumpkins and gourds are widely cultivated and contribute to more than $400 million in revenue annually. These crops rely on bee pollination for fruit set and crop yields. While some growers stock their fields with managed honey bee hives to aid in pollination, recent work has suggested that wild bees are able to provide more than adequate pollination for fruit set for pumpkin farms in Pennsylvania. However, little is known about what stressors may impact wild bees in these agricultural landscapes, or what management practices may help buffer them from stress. **The goal of this project is to identify and measure how stressors like extreme temperature, pathogen pressure and pesticide exposure impact one of the most significant cucurbit pollinators in Pennsylvania—the squash bee.** We also suggest management practices that may help attract and protect these bees in squash and pumpkin fields.

Squash bee biology: The squash bee (Eucera (Peponapis) pruinosa) is an important contributor to the pollination of squash and pumpkin for farms across the United States. As suggested in the name, these bees have a unique relationship with squash, pumpkins and gourds in that they exclusively collect pollen from the plant genus Cucurbita, though they will collect nectar from other plants such as morning glories, blackberries, cucumbers or melons. Squash bees share the same life history traits—solitary and ground nesting behavior—as 70% of all bees. Each female squash bee digs an individual nest underground to lay eggs. These babies will overwinter underground as pre-pupae and emerge as adults the following summer. Both males and females persist throughout their active season as adults. In Pennsylvania, adults are typically active between early July and early September. When present on a farm, squash bees are often found at high densities and both sexes are significant contributors to pollination. However, like many bees, they may be facing threats from changing climate, pathogen pressure and pesticide exposure in these agroecosystems.

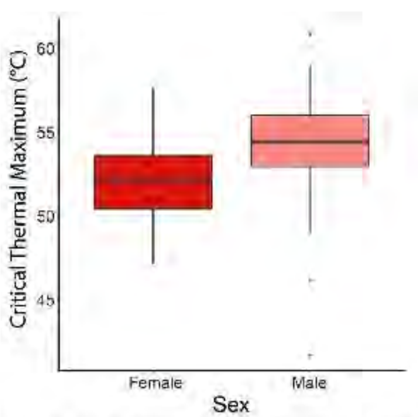

Figure 1. The critical thermal maxima of female (dark) and male (light) squash bees collected in Pennsylvania (2021).

Temperature stress: Squash bees experience vastly different daily temperature conditions, and may not be as well buffered from this temperature variation as other bees. For example, honey bees (Apis mellifera) will work together to warm or cool their hives in response to temperature extremes. While female squash bees can buffer themselves from extreme temperatures by retreating to their individual ground nests before midday, the only refuge available for males is inside of wilted pumpkin or squash flowers which they will chew their way out of the next day. Due to these different behaviors that the female and male squash bees exhibit, we wanted to test if males are more susceptible to heat stress than females in Pennsylvania due to their limited ability to buffer from extreme temperatures, and in contrast, if the females are able to buffer themselves more effectively. To do this, we measured the critical thermal maxima, or upper temperature limit that the bee could withstand before severe agitation, of squash bees across 14 farms in

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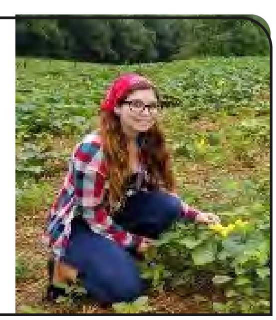

Pennsylvania. **We found that male squash bees collected at warmer sites had a higher heat tolerance than males at cooler sites, which may suggest that they are acclimating to warmer conditions in Pennsylvania rather than being heat stressed.** The heat tolerance of female squash bees was not predicted by environmental temperature, which likely indicates they are not experiencing heat stress, either (see Figure 1 for sex comparison). We still need to learn more about how changing temperatures may influence heat tolerance in these bees, and we will continue investigating how changing climate conditions may impact squash bee persistence across their range.

Pathogen pressure: Managed bees (such as honey bees) and wild bees often interact in agroecosystems because they share the same floral resources. In Pennsylvania, squash bees, bumble bees (namely Bombus impatiens) and honey bees are the most frequent visitors to squash and pumpkin farms and contribute the bulk of pollination services. There has been growing concern about the role of honey bees in transmitting pathogens to wild bees in agricultural fields, particularly as honey bee pathogens have significantly increased in recent years with the introduction of the varroa mite to the US in the late 1980s. We collected squash bees, bumble bees and honey bees from 14 farms in Pennsylvania to screen for pathogens that are associated with honey bees to test which bees are carrying these pathogens and how their infection levels compare. We used quantitative PCR to screen for three viruses and three gut parasites. The viruses we screened for—deformed wing virus, Israeli acute paralysis virus, and Kashmir bee virus—have been detected in bumble bees and are known to reduce overwintering survival for honey bees. In addition, we screened for a bacterial parasite, (Spiroplasma), a trypanosome parasite (Crithidia) and a microsporidian parasite (Vairimorpha, formerly known as Nosema), which all infect the gut and cause sublethal symptoms like dysentery. Overall, we found that viruses were detected in significantly fewer squash bees than the other two bees, and they had lower infection levels than honey bees (see Figure 2). In contrast, more squash bees appear to have the bacteria Spiroplasma than the other two bee species, and at much higher levels. Likewise, the gut parasite Crithidia was found at higher levels in squash bees than bumble bees, and Vairimorpha was found at higher levels in squash bees than either bumble bees or honey bees. **Our results so far suggest that squash bees are not easily infected by honey bee viruses, though they are carrying high levels of many gut pathogens. However, squash bees are likely suitable hosts for other pathogens that are less common in managed bees like honey bees.** We didn't assess if squash bees experience any disease symptoms in this study, though we will continue to investigate the impacts of these pathogens on squash bee health with the knowledge we now have of their presence and infection levels.

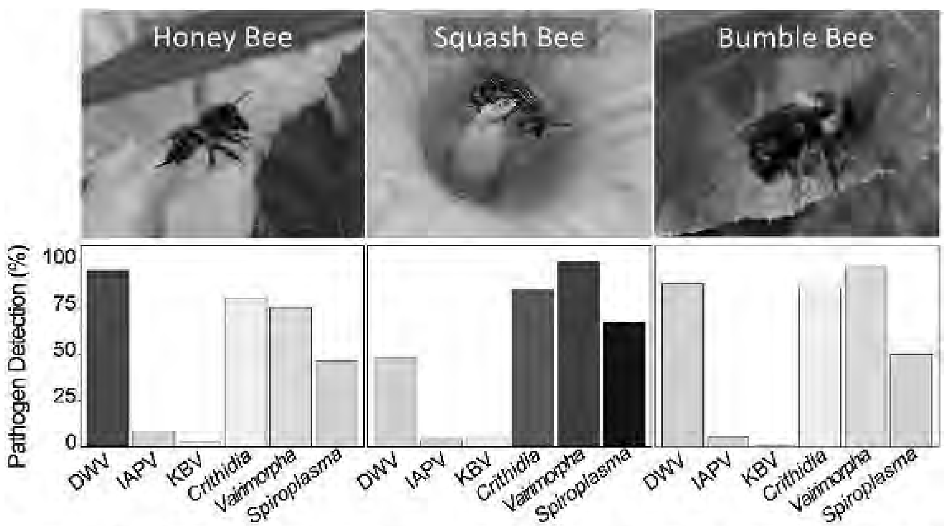

Figure 2. Pathogens detected in honey bees, squash bees and bumble bees collected from pumpkin fields in Pennsylvania (2019). Dark bars for DWV in honey bees and Crithidia, Vairimorpha *and* Spiroplasma *in squash bees indicate high infection levels in those bees screened.*

Pesticide application effects: Pesticide exposure has been identified as a serious threat to many pollinating bees visiting agricultural fields, though the impact of pesticides on ground nesting bees is not well understood. In one study, squash bees collected in Ontario, Canada were exposed to neonicotinoid-treated squash plants for two years inside of hoop houses. The squash bees exposed to soil-applied imidacloprid insecticide were found to produce significantly fewer offspring over both years. In contrast, squash bee reproduction seemed unaffected when plants were treated with seed-coatings of thiamethoxam or foliar sprays with chlorantraniliprole. **These findings may suggest that squash bees are more susceptible to pesticides when they are applied to the soil.** In Pennsylvania, we took two soil cores from 14 farms in mid-September of 2019, one on the edge of the pumpkin field and one in the interior, to see if any significant pesticides were persisting in the soil. We found small amounts of imidacloprid and thiamethoxam in the soil at only a few farms, and small amounts of clothianidin and varying amounts of fungicides (including 4-Hydroxy-chlorothalonil, azoxystrobin, boscalid and pyraclostrobin) at about half of the farms we visited. We didn't find that the concentration of these pesticides or fungicides impacted the number of squash bees we detected at these sites, though we also couldn't confirm if they were nesting in the soil that we collected for our tests. More work is necessary to identify which pesticides and application methods may be the safest for squash bees while still managing pests and disease in squash.

Management practices to help: Overall, squash bees in Pennsylvania seem to be buffered well from pressures from climate, pathogens and pesticides on squash and pumpkin farms. We have found several strong squash bee populations throughout the region despite some sites having bees with high pathogen infection levels, or even detecting high pesticide or fungicide levels in the soil (see Figure 3). The bees at these farms may have an advantage compared to other wild bees that helps them buffer against stressors—they are not nutrition-limited since there is an abundance of their host plant being produced in one place. There is still work we can do to keep Pennsylvania squash bees happy and healthy as conditions change, or to attract squash bees to your farm if they aren't already there. We suggest planting cucurbit fields close to the location of the previous year's field to maintain proximity so the squash bees can easily find their new host plant source once they emerge. Likewise, providing a margin of bare, disturbed ground near cucurbit fields can aid in nesting, and keeping the positioning of black plastic consistent across years will protect emerging bees from being trapped beneath. Minimizing pesticide exposure by rotating crops each year to fields where neonicotinoids were not applied the year before, or integrating non-chemical pest management into pest control programs, may also help reduce the risk of pesticide exposure to squash bees. Monitoring squash bee populations for pathogens and parasites, including observing bees foraging to see if they display disease symptoms, is another great tool to assess how they are doing. Lastly, providing alternative plants nearby, including wildflowers, shrubs or forest, can give squash bees areas with shade to buffer themselves from extreme temperature conditions.

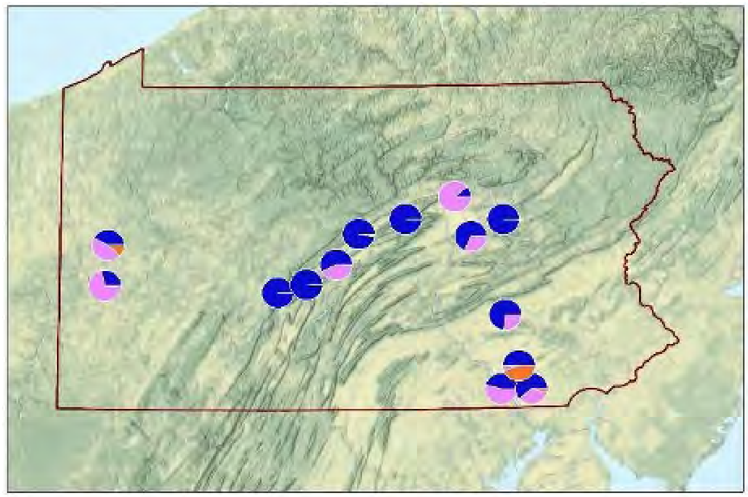

Figure 3. Proportion of squash bees (blue), bumble bees (pink) and honey bees (orange) found visiting pumpkin flowers in Pennsylvania (2019).

To learn more about squash bee biology and what management strategies you can implement to enhance their populations, check out the Biology & Pollination Services of the Squash Bee Eucera (Peponapis) pruinosa booklet: https://lopezuribelab.com/squash-bee-biology.

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TARPING TO REDUCE TILLAGE IN SMALL-SCALE ORGANIC VEGETABLES

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Tarping has recently emerged as an accessible and multifunctional management tool for small-scale and organic vegetable farms. Tarping, or occultation, involves the use of large black plastic, often sourced as silage covers (32' x 100'; 5-6 mil thick), that is applied to the soil surface and removed before planting. Tarps are low-cost, reusable over multiple years, and adaptable to different applications and planting times in a vegetable crop rotation. Tarps are generally left in place for 3-4 weeks, though this duration varies based on tarping goals and time of year. For example, some farmers use shorter durations, 1-2 weeks, in high tunnels and warmer mid-summer periods and longer durations, 6+ weeks, when killing sod, suppressing perennials, and overwintering. Tarps often serve as both a weed and soil management tool – holding beds weed-free between plantings, creating a stale-seed bed for weed prone crops, and preparing soils for planting. In the Northeast, this "placeholder" function is especially valuable in late fall and early spring, when soils are often too wet for field operations, increasing field access. Many of the challenges associated with tarping are logistical, including applying and securing them, moving them across fields, water ponding, and finding time in the rotation to fit them, especially in the middle of the season.

Reduced tillage (RT) practices can take many different forms with tarps. After beds are tilled, tarps can maintain the desired planting conditions and suppress weeds until planting time without supplemental passes. By reducing passes, tarps reduce the frequency of disturbance, save equipment time, and potentially improve field access at times when soil conditions would otherwise be too wet to plant. Tarps also create opportunities to use shallower tillage, reducing the amount of soil disturbed by more than 50%, by helping to kill and suppress living weeds. When they effectively reduce annual weed emergence for the following crop, tarps can also reduce cultivation passes and/or allow for less aggressive tools. Tarp have also shown to be a viable no-till (NT) practice by providing many of the bed preparation services typically provided by tillage. Tarps can fill a NT niche by creating weed-free planting conditions for the following crop without relying on heavy applications of organic mulches (e.g., hay, straw, leaves, or compost), materials that are not appropriate for short season or direct-seeded crops and can be difficult to source and labor intensive to apply. While a growing number of farmers are using tarps, there are many questions about what's happening under them and how they can be used effectively in different applications. Our research has been trying to answer these questions to learn how we can use tarps to be successful with RT and NT organic vegetable production.

Tarps improve the soil environment for planting in several ways. We have found tarps increase average soil temperatures by several degrees when compared to bare, untarped ground. These temperature changes can add up over several weeks, increasing total soil degree days (base 40°F) by 10-30% depending on the season of application. Tarps also regulate soil moisture conditions by excluding rainfall and maintaining relatively constant soil moisture over the tarping period. When conditions are very dry, irrigating prior to tarping can help ensure moisture is not limiting. These changes to the soil environment are likely to increase soil biological activity and nutrient mineralization. Often NT and RT practices lead to lower soil nitrogen availability compared to conventionally tilled soils. Our research has shown that crops can inherit a large amount of plant-available soil nitrogen after tarps, with levels increasing with longer durations. When comparing tarped to untarped soils, we have found soil nitrate levels 2-4 times higher after short tarping durations (3 weeks) and more than 10 times higher when applied overwinter. This result is also likely driven by the impermeability of tarps such that mobile soil nutrients are not subject to leaching while tarps are in place. By retaining soil nitrate for the following crop, tarps may serve to improve crop establishment and reduce early season fertilizer nitrogen needs.

Residue management often complicates RT and NT operations and tarp effects on crop residues and decomposer organisms are not well documented. Many farmers have observed faster decomposition under tarps and greater earthworm activity. By mowing residues and applying tarps directly over harvested crops, tarps can make it easier to manage beds between plantings. In low residue situations, like leafy greens, or when transplanting, it's often possible to plant directly into tarped soil with no tillage between crops. Tarps often need to be combined with other strategies to manage residue before establishing the following crop, including selecting the appropriate crop type (e.g., direct seeded vs transplanted), modifying available planting tools or equipment, and physically cutting and/or removing plants (e.g., brassica stalks are tough). Our research applied tarps directly over an oat cover crop and showed no changes in residue cover after 3, 6, and 10+ weeks of tarping. In this case, raking residues into pathways after tarping can facilitate direct seeding.

Tarps are a promising strategy for the management of annual weeds. Across multiple research trials, we have found that a 3-4 week tarp was sufficient to kill all pre-emerged annual weeds prior to planting, similar to tarps of longer duration. Tarps can also create a stale seed bed and reduce the emergence of annual weeds in the following crop through "fatal germination":

where warm moist conditions under the tarp stimulate seed germination, followed by seedling death as they are starved for light. Recent trials have shown that tarps can reduce annual weed emergence and competition in the following crop by at least 50%. In this application, it is important to minimize soil disturbance after tarp removal to avoid the introduction of new weed seeds to the soil surface. Our research has also shown that tarps can effectively draw down the weed seedbank over time. This is likely the combined result of tarps: 1) increasing fatal germination, 2) suppressing weeds between crops that would otherwise produce seed, and 3) in the case of continuous NT applications, controlling the introduction of weed seeds from greater soil depths. Despite these tarping benefits, complementary weed management tactics are often needed, especially for controlling weeds in long-season crops and to effectively control perennials.

Tarps can be paired with cover crops to add organic matter and living roots and lead to greater soil health benefits. When tarps are applied over winter killed cover crops (established in late summer) by late fall or early spring, they can be used to improve nutrient retention and recycling and control weed escapes. We have found that tarps applied to an oat cover crop enhanced winter annual weed suppression and significantly increased soil nitrate levels ahead of spring cash crop planting. In the case of a fall established winter hardy cover crop, tarps can serve as an effective termination strategy without repeated tillage events, and we have found that tarps can kill cereal rye after 3 weeks between late April and mid-May. When cover crop planting windows close, in the case of late fall harvested vegetable, tarps can be used to complement these practices and armor bare soil and crop residues in preparation for planting early spring crops.

BREEDING FOR YEAR-ROUND LETTUCE PRODUCTION AND ITS MULTIPLE CHALLENGES

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Everglades Research and Education Center. Horticultural Sciences Department. Belle Glade, FL

Lettuce (*Lactuca sativa L.*) is a crop with a high farmgate value in the United States. Most of the lettuce consumed across the nation is produced in field operations and represents a 3.5-billion-dollar business industry that is mostly concentrated in the states of California, Arizona, and Florida (95%) but production of this vegetable occurs throughout the nation (5%), especially in the spring and fall seasons. The crop is also a preferred commodity in protected structures, an industry in constant development that can provide lettuce for year-round consumption. Lettuce is among the top-ten most consumed vegetables and can be found in salads, garnishes and staple ingredients of fast-foods such as burgers and sandwiches. Lettuce can even be cooked in certain dishes, although consumption of this vegetable mostly occurs in a raw form. The vegetable can be a source of several key vitamins and minerals for the human body but the proportion of these beneficial compounds in lettuce are not as high as in other leafy vegetables; however, the relatively higher intake of lettuce may offset the smaller proportion of these compounds.

U.S. consumers obtain year-round lettuce from two of the main producer states, California and Arizona, but an increase in the world population to over 10 billion people by 2050 warrants a search for newer crop production systems to alleviate the many constraints faced by the lettuce industry. In the U.S. alone, the number of people is estimated to be over 400 million by the year 2050, and most of these people are projected to live in larger urban areas. In addition, consumer preferences may change in the near future as they demand fresher vegetables with higher nutritional value that are produced in nearby areas. Not only are consumer dynamics in flux, but climate patterns are predicted to be more extreme. The changes in climate pattern will pressure plant breeders to improve crops, including lettuce, to be adapted to evolving challenges including warmer or cooler production systems, and the appearance of diseases that previously were not a threat for lettuce production.

These trends compound the many challenges lettuce already faces. Lettuce is a cool season crop that performs well in temperatures below 80 °F. The warmer temperatures have shortened lettuce production seasons like the one in Florida or impeded the planting of this crop in the summer in northern states, like in Michigan. In addition, warmer temperatures cause reduced seed germination in fields, physiological disorders such as bolting and tipburn and facilitates the proliferation of pathogens causing diseases including Lettuce Dieback. Therefore, growers cannot provide lettuce year-around as heat-tolerant lettuce cultivars are still being developed by plant breeders which can germinate and produce marketable heads in warmer conditions.

In addition to climate constraints, lettuce is susceptible to many diseases and insect-pests that diminish yield. Many of these biotic stresses are sporadic and have limited control measures, therefore improving cultivars with resistance to diseases and pests is a priority for lettuce breeding programs. While there are many diseases affecting the lettuce crop, one of critical importance is Bacterial Leaf Spot (BLS) caused by the bacterium Xanthomonas hortorum pv. Vitians. This bacterial pathogen affects lettuce in subtropical climates or when the crop is planted in warmer environments as in summers in the Mid-Atlantic region. BLS has been reported in Florida, California, the Mid-Atlantic region, northeastern USA and in Canada. The pathogen presents three races thus far and resistance has been identified to all these races. Improving lettuce against BLS is a target in lettuce breeding programs across the nation, especially for subtropical and warmer environments where resistance to BLS is needed.

Other diseases that challenge lettuce for year-round production include Lettuce Downy Mildew (LDM) caused by the patho-

Germán V. Sandoya, a native of Ecuador, is an assistant professor in breeding and genetics and a Florida statewide extension specialist positioned at the Everglades Research and Education Center and the Horticultural Sciences Department at the University of Florida - IFAS. His mission is to develop lettuce (and other leafy vegetables) breeding lines and cultivars adapted and improved to the unique environmental conditions of the state of Florida and other areas where lettuce is cultivated. He obtained a Ph. D. in Breeding and Genetics by the University of Vigo in Spain and is very familiar with the Mid-Atlantic region as he was a postdoctoral researcher at the Penn State University in University Park, PA. After a 3-year period, he moved to the University of California, Davis based in Salinas, California "The Salad Bowl of the World" where he started a second postdoc and then became a project scientist working in lettuce breeding and genetics. He is currently the leafy vegetables breeder at the University of Florida and belongs to one of the biggest public plant breeding groups in the U.S.

gen *Bremia lactucae, Cercospora* Leaf Spot (CLS) caused by *Cercospora longissima* and soil-borne pathogens that have spread to regions with no previous reports of these diseases. LDM is perhaps the most challenging disease in lettuce as the pathogen is in constant evolution. To date, 10 races of B. *lactucae* are present in the western production areas in the U.S. and no information on the race structure is known in the rest of lettuce production areas. CLS is a disease that is becoming a threat to lettuce production in subtropical areas and perhaps will be a threat to summer production systems. The disease is already present in greenhouse production systems as not many strategies are available for controlling this pathogen.

While field producers will continue to supply lettuce to markets throughout the U.S., a relatively new production system will complement the needs of this vegetable, especially for an increasing and demanding population. According to the USDA census of 2017, 43% of the area to produce *food crops grown under glass and other protection* was dedicated to vegetables and fresh cut herbs including lettuce. Lettuce is perhaps the most planted vegetable in protected structures including hydroponics, aeroponics and vertical farms. Although, production costs of lettuce in these systems are cheaper than several years ago, there is still room for improvement to lower the costs associated with producing in protected structures. Certainly, these structures will help supply lettuce to markets when field producers cannot meet the demanding quote due to unforeseen events including disease and weather-related issues. Breeding lettuce cultivars for year-round production will be accomplished by targeting many of these challenges producers, field or greenhouse, face to provide a product that is fresh and appealing to consumers.

HERBICIDE ACTIVITY, SYMPTOMOLOGY, AND OFF-TARGET MOVEMENT

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Herbicides are effective tools for managing unwanted vegetation across cropping systems. Data from the US Environmental Protection Agency (EPA) indicates that, historically, herbicides have been applied to more cropping acres than insecticides, fungicides, or other pesticides. The effective use of these chemistries is enhanced by understanding about how herbicides are applied and work, the injury symptoms they cause, when they fail, and how they move and cause damage to off target plants.

Definitions:

Active ingredient: This is the molecule that possesses the herbicidal activity. The chemical name of the molecule describes its structure (for example: 6-chloro-N-ethyl-N'-(1-methylethyl)- 1,3,5-triazine-2,4-diamine); more often, the active ingredient is referred to by its common name (which, in this case, is atrazine). The trade name is the brand name of a commercialized herbicide product contains one or more active ingredients but also other products like stabilizers or adjuvants. An active ingredient may be available under multiple trade names that can differ dramatically in their formulation, rate structure, etc… (i.e. Aatrex 4L, 90DF, Atrazine 90WDG)

Herbicides can be defined by the placement of applications. Soil-applied or pre-emergence herbicides are incorporated into the soil solution and act on the soil that contact newly germinated of emerging weeds newly germinated seeds – often killing them right before or soon after they emerge from the soil. These products are often referred to as residual herbicides because they can persist in the soil and retain herbicidal activity or weeks or months, depending on their chemistry and biological, edaphic, and environmental conditions. Even though many of these products have little activity on already emerged plants, some are still capable of causing injury to aboveground tissue.

Foliar applied or post-emergence herbicides are applied directly to emerged plant tissue. They can be contact products that cause direct damage only to treated foliage or systemic products that move (i.e. are translocated) within a treated plant through the xylem or phloem to their sites of action. Post-emergence products may also be referred to as 'topical' or 'over-the-top' herbicides. Typically, systemic materials work better on established perennial weeds than contact materials, but symptoms are also slower to develop.

Herbicides can be selective or nonselective. A non-selective herbicide is also referred to as being 'broad-spectrum'; e.g. it is capable of controlling many different types of weed species. Selective herbicides are effective at controlling some weed species, but not others; for example, a herbicide that is effective mostly broadleaves but not grasses or vice versa.

Sites and modes of action are sometimes used interchangeably, but they do have different meanings. Sites of action refer to the specific target site of the herbicide whereas mode of action refers to the overall manner in which a

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herbicide affects a plant. How herbicides interrupt plant processes influence the types of symptoms that we ascribe to certain chemical groups. For example, the PPO inhibitors block the production of chlorophyll and result in the production of reactive molecules destroy lipids and protein membranes, allowing the cells to become leaky and, ultimately, tissues to disintegrate. PPO-inhibitor injury symptoms start off as water soaking followed by tissue necrosis.

Herbicides do not always work as intended, for many reasons including the evolution of *herbicide resistance*. According to the Weed Science Society of America, herbicide resistance is the "inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis." According to the International Survey of Herbicide Resistant weeds (www.weedscience.org) "There are currently 509 unique cases (species x site of action) of herbicide resistant weeds globally, with 266 species (153 dicots and 113 monocots). Weeds have evolved resistance to 21 of the 31 known herbicide sites of action and to 164 different herbicides. Herbicide resistant weeds have been reported in 95 crops in 71 countries." Herbicide resistance develops when an active ingredient or chemical class is used repeatedly over time and space (i.e. selection pressure). Natural mutations that reduce herbicide efficacy become more dominant in a weedy population as sensitive individuals die off and resistant plants survive, set seed, and dominate the seedbank. It is important to note that not all instances of herbicide failure can be attributed to resistance; improper choice of herbicide or application strategy, incorrect rate selection or adjuvant usage, malfunctioning or uncalibrated equipment, plant stress that reduces herbicide uptake and/or activity, and environmental conditions that impact herbicide deposition or activation can all affect performance.

Herbicides may not only affect target species. Residues that remain in the soil can result in *carryover* that can injure rotational crops. Off-target movement via drift can be broken down into *particle (or spray) drift and vapor drift. Particle drift* occurs when herbicide spray is physically moved (i.e. via wind currents). Vapor drift occurs when a herbicide volatilizes off of a sprayed surface under temperature and humidity conditions that facilitate it. While vapor drift is a function of the herbicide chemistry, environmental factors and applicator choices can influence the occurrence.

UNDERSTANDING AND MITIGATING PESTICIDE RESISTANCE

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Pesticide resistance is a shift in the genetics of a pest population that allows individuals within a previously susceptible population to survive after exposure of a pesticide. It can affect all pest groups, including insects, mites, fungi, bacteria, nematodes, weeds, and rodents. By reducing the efficacy of pesticide application, resistance can complicate management of pests within crops. The first documented case of resistance to a pesticide was for weeds in 1957, though the problem has certainly become more and more common in agriculture since then. There are now over 230 cases of resistance in weeds alone.

Pesticide failure, where a pesticide does not perform as expected, can occur due to weather impacting the application success and ability to stick, incorrect timing or method of application, malfunctioning equipment, using the wrong rate, or simply choosing the wrong pesticide for the pest you're trying to manage. In addition, some populations or individuals of pests will have natural tolerance to a pesticide, where they are able to survive and reproduce after an insecticide application. What sets resistance apart from these scenarios is that it indicates a pesticide that was effective against a population previously but is no longer effective because of the shift in genetics that determine susceptibility of the population to that pesticide, even when the pesticide is applied at the right time, with the right equipment, at the correct rate, and without any weather concerns.

Resistance most often develops in response to pesticides that are initially very effective and frequently used. Factors that increase the risk of resistance development include not rotating crops, making multiple pesticide applications to achieve season-long control, having limited options to achieve control, relying on one single active ingredient for control, or rotating with crops that are equally susceptible to the pest. In the case of weed management, rotating an herbicide-resistant crop with another crop resistant to the same herbicide can increase the risk. All of these result in repeated exposure of a pest population to the same active ingredient. The speed at which resistance develops depends on the characteristics of the pest, the characteristics of the pesticide, and the characteristics of the cropping system being managed.

To prevent this from happening, we need to be judicious with our use of pesticides and make careful decisions about what to use and when if we are experiencing a problem with pests. Resistance management needs to be a priority early on, prior to field failures becoming obvious. Once you notice the problem occurring, it is often too late to prevent resistance from developing. To reduce the risk of developing resistance, scout for pests and only use a pesticide when necessary, once pest densities have reached a threshold needing control. Implement an integrated pest management approach, starting with preventative tactics to prevent pests from establishing, followed by mechanical, cultural, or biological control tactics. If these tactics are not enough to control a pest and chemical control is warranted by the pest densities, use pesticides with different modes of action when possible, particularly if multiple applications are necessary within a season and rotate between the different modes of action. When you choose to apply a pesticide, make sure you are applying at the correct rate for the pest you're trying to control. If you apply a

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rate that is insufficient for the pest you're managing, more individuals are likely to survive through tolerance and contribute to the development of resistance over time. If you manage your crop to prevent pest establishment, are judicious with when you use a pesticide, rotate ingredients as much as possible, and follow recommendations to ensure the best success of the pesticide you are using for each pest you are managing, these strategies will reduce the risk that pesticide resistance will develop.

This content was prepared by Bill Riden, in partnership between Penn State Extension Pesticide Education Program and Pennsylvania Department of Agriculture and presented by Karly Regan.

CAN DIRECT-MARKET VEGETABLE FARMERS MAKE A MIDDLE-CLASS INCOME?

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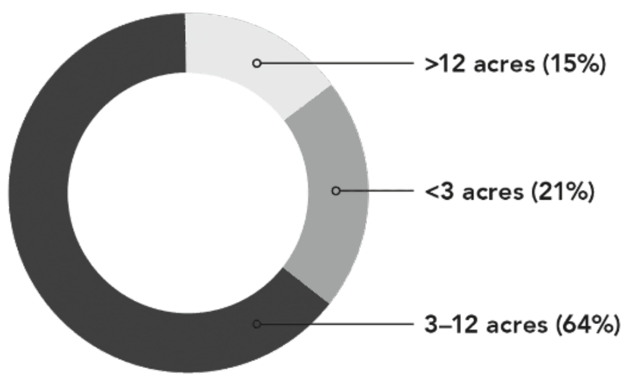
Vegetable farms that sell their produce through farmers markets, CSA programs, on-farm stores, and other direct-market channels are the foundation of local food movements everywhere. Yet there is surprisingly little information available to help answer a basic question: Can farmers make a middle-class income selling vegetables through direct-market outlets? We launched an ongoing study in 2017 to help fill this critical gap in information and provide insights that could help vegetable farmers start and grow their businesses. Our new report offers the most comprehensive review of direct-market vegetable farm businesses to date, sharing detailed financial benchmarks from 39 farms collected over three years. Participating farms were located in four Mid-Atlantic states: Pennsylvania, Maryland, Virginia, and West Virginia. Most had less than 15 acres in vegetables production; the largest had approximately 100. Farms studied had been in business for anywhere between one and 50 years.

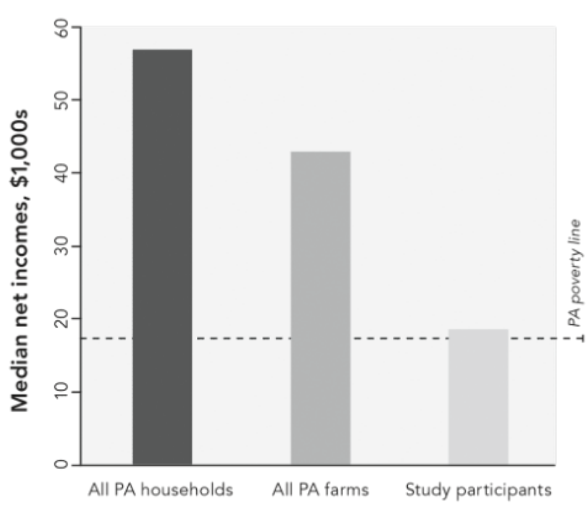
STUDY PARTICIPANTS: ACRES IN VEGETABLES PRODUCTION



Findings

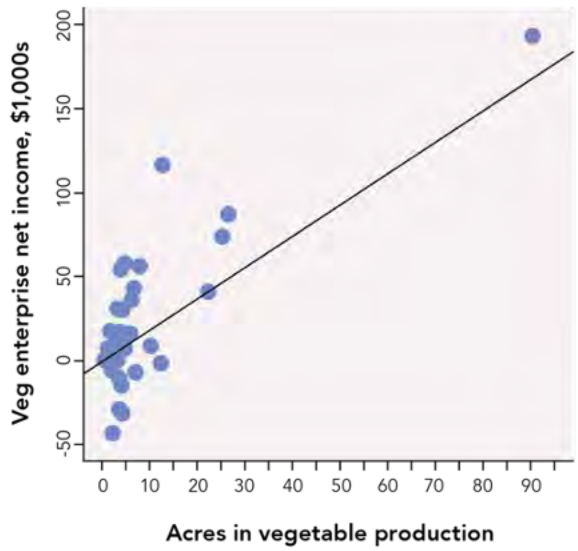
Our findings were consistent with structural challenges that negatively impact small- and medium-scale farms in a highly consolidated agriculture industry. In other words: They were sobering. We found that the majority of direct-market vegetable farms were not earning a middle-class income. Participating farms had a median net income of $18,500, which approximates the 2020 poverty rate in Pennsylvania for a two-person household. Further, the net incomes of more than 70% of the farms in our study were less than half the median net income for all Pennsylvania farms, which include among others dairy, row crop, and wholesale vegetable operations.

MEDIAN NET INCOMES FOR PA HOUSEHOLDS, FARMS & STUDY PARTICIPANTS



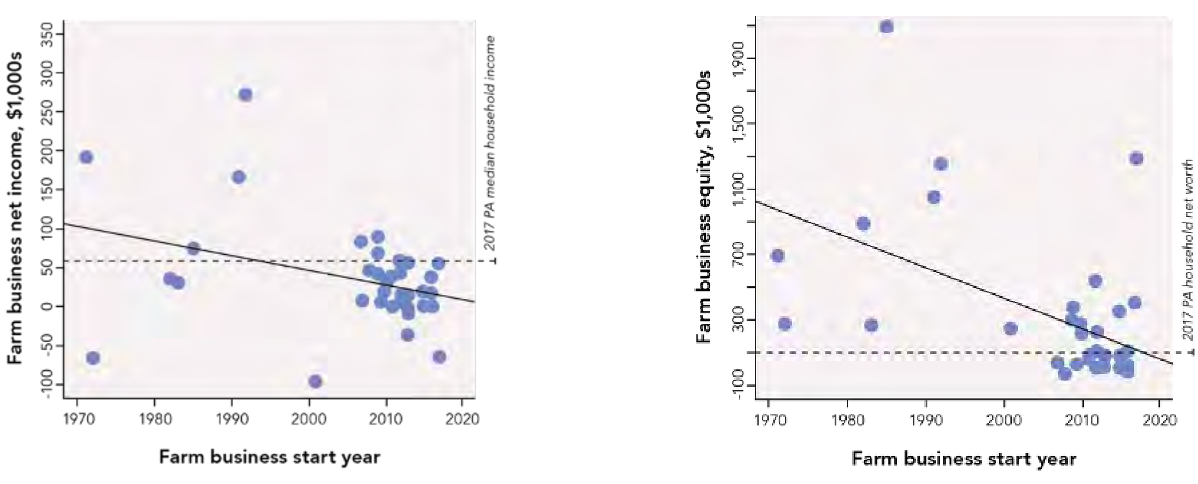
We did find some farms bucking the trend. A quarter of study participants had earned net incomes greater than the Pennsylvania median household annual income of $57,000. These farms tended to be larger in scale than many market-garden-style farms—typically, ten acres or more in vegetable production—and often capitalized on diversifying their revenue streams, with reselling products produced by other local farms proving to be one of the more profitable added enterprises. Notably, however, many of the owners of these high-performing farms partially attributed their success to good fortune, such as access to especially lucrative markets or reliable farmland arrangements.

VEGETABLE ENTERPRISE NET INCOME RELATED TO ACRES IN VEGETABLE PRODUCTION



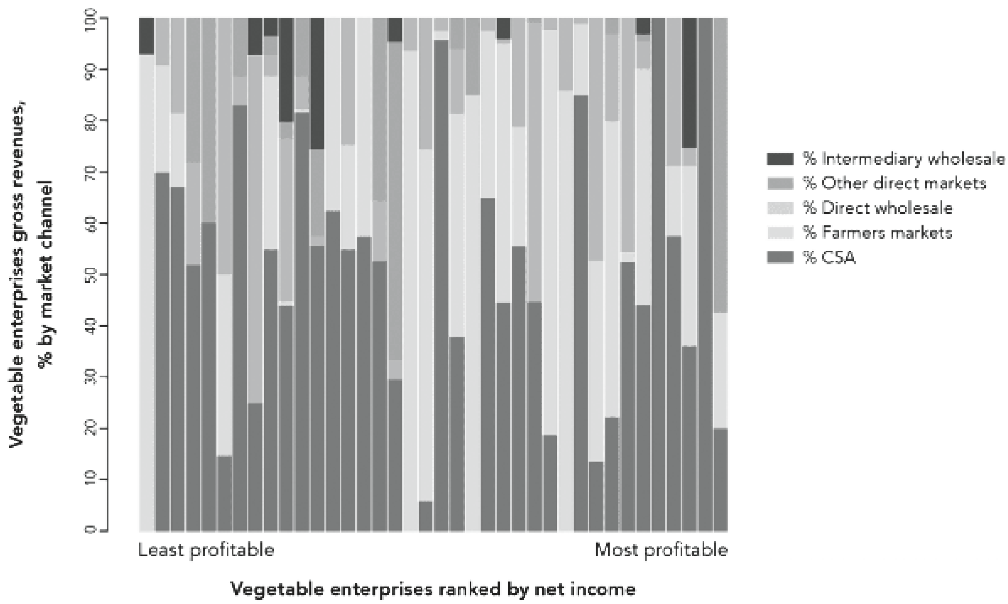
We also found that farms steadily increased income and equity over time, generally becoming more profitable the longer they were in business. Most farms' net incomes exceeded the Pennsylvania median household income within 12 years of business, while accumulating equity in land, buildings, and equipment in the meantime.

FARM BUSINESS NET INCOME (LEFT) & EQUITY (RIGHT) RELATED TO NUMBER OF YEARS IN BUSINESS



Interestingly, no single direct-market channel consistently outperformed all others. We found that all of the major sales channels utilized by farms in the study—farmers markets, CSAs, and direct wholesale—had a mix of higher and lower income cases. For farmers wondering whether or not to focus on selling their produce through particular direct-market channels, this finding indicates there isn't a one-size-fits-all business model for financial success.

NET VEGETABLE ENTERPRISE INCOME & MARKET CHANNEL COMPOSITION



Pathways to higher incomes

We identified three primary pathways for improving direct-market incomes: (1) increasing the number of acres in vegetable production; (2) growing more and higher-value crops per acre; and (3) developing more efficient production systems. Still, the land, labor, and capital needed to pursue these strategies may be out of reach for farmers who are operating at a loss or aren't earning a living wage.

SCENARIOS FOR ACHIEVING A NET INCOME GOAL ($56, 951) BY INCREASING SCALE, INTENSITY, OR EFFICIENCY

Scenario	SCALE *(acres in vegetable production)*	INTENSITY *(gross revenue per acre in vegetable production)*	EFFICIENCY *(vegetable net income to revenue ratio)*	Vegetable enterprise net income
Baseline	10	$27,589	12.5%	$34,486
1. Increase scale	16.5	$27,589	12.5%	$56,951
2. Increase intensity	10	$45,561	12.5%	$56,951
3. Increase efficiency	10	$27,859	20.4%	$56,951

farmers want to operate profitable, self-sustaining businesses, the financial benchmarks identified by our study are consistent with industry structural challenges that negatively impact small- and medium-scale farms. Creating and expanding public and private programs and partnerships will be necessary to help direct-market vegetable farmers continue their essential work providing fresh, nutritious food for their communities.

These programs and partnerships should focus on equitably increasing farmland access, improving market opportunities, encouraging workforce development, reducing financial risk, and rewarding conservation best practices such as building soil health, protecting wildlife, and improving water quality.

What's next?

Our financial benchmarking research is ongoing. Since compiling the findings detailed in our new report, we've partnered with peer organizations in New England (Community Involved in Sustainable Agriculture) and the Carolinas (Carolina Farm Stewardship Association) to expand the scope of our study to include data from vegetable farms located outside of the Mid-Atlantic region. We will also be analyzing the impact the coronavirus pandemic has had on study participants. You can access the full report, Financial Benchmarks for Direct-Market Vegetable Farms: 2021 Report, at www.pasafarming.org.

Our Financial Benchmarks Study was initially made possible with investments from Lady Moon Farms, the Jerry Brunetti family, the Shon Seeley family, and more than 120 private donors committed to strengthening local and regional food systems. Additional support was provided by a Pennsylvania Department of Agriculture Specialty Crop Block Grant and a Pennsylvania Department of Agriculture Research Grant.

Want to join this study?

If you are a direct-market vegetable farmer and are interested in joining this study, email us at research@pasafarming.org. Participating farms get custom financial benchmark reports and access to a learning community of their peers.

Presenter: Sarah Bay Nawa is the Research Coordinator for Pasa Sustainable Agriculture where she supports farm-based research on issues including soil health and financial viability. She has more than a decade of combined farming and farm-advising experience from New Morning Farm, the Fulton Farm at Wilson College, and Tuscarora Organic Growers Cooperative. Sarah holds a B.S. in environmental science.

EVALUATING CARBON SOURCES FOR ASD IN HIGH TUNNEL PRODUCTION IN PENNSYLVANIA

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Anaerobic soil disinfestation (ASD) is one of the most promising non-synthetic approaches for the simultaneous management of soilborne pathogens, plant-parasitic nematodes, and weeds. It is a biological solution to address soil health issues that can result from intensive cultivation systems and is suitable for both organic and conventional production systems. Developed at the same time in Japan and The Netherlands, ASD is now being commercially applied in China, Europe, and the USA (California and Florida). Other states in the US that are researching for the optimization of ASD for their pedoclimatic conditions and crops of interest include Tennessee, Maryland, North Carolina, Ohio, Virginia, Washington, and Pennsylvania. In Pennsylvania the primary interest in implementing ASD is the management of emerging soilborne pests and pathogens affecting vegetable and small fruit crops grown in high tunnels. High tunnel production systems offer limited opportunities for crop rotation, cover crops, and other soil health conservation practices, thus leading to increased incidence of soilborne pathogens and pests. ASD is applied 3-4 weeks before planting by incorporating a labile carbon source into the soil, mulching the soil with totally impermeable film to limit gas exchanges between soil and atmosphere, and finally irrigating the soil to saturation. In this way, the carbon source incorporated in the soil is readily metabolized by soil microbes generating anaerobic conditions and biochemical compounds that are toxic or suppressive for several soilborne plant pathogens, nematodes, and weeds.

Being ASD a microbial-driven process, soil temperature is a factor that can enhance or limit soil microbial activity and hence the development of anaerobic conditions during the ASD treatment. Achieving persistent and prolonged anaerobic conditions is critical for the effectiveness of the ASD treatment. Soil temperatures below 60 °F can limit microbial growth and metabolic activity even when there is a readily decomposable carbon source, limiting in turn the efficacy of the ASD treatment. Therefore, when applying ASD in the Mid-Atlantic region soil temperature should be considered in defining the timing of the application.

Another critical aspect for the implementation of ASD is the selection of locally available, low cost, easy to apply, and readily decomposable carbon sources. The ideal carbon source should also have an adequate concentration of nitrogen and relatively low levels of other minerals to provide nutrition for microbial growth while avoiding excessive inputs of other nutrients. In the regions where ASD is currently being implemented commercially, the carbon sources used are primarily wheat bran, rice bran, sugarcane molasses, and ethanol. However, organic by-products of the agri-food industry may be suitable sources of carbon.

A study was conducted in the fall of 2020 at the Penn State Russell E. Larson Agricultural Research Center, with the objective of testing four by-products of the Pennsylvania agri-food industry as carbon sources. The alternative carbon sources tested were: spent mushroom compost, edamame residue, wheat middling, and brewer's spent grain and were compared with sugarcane molasses and an untreated control. Application rates for each carbon source were defined based on the total C content applying the equivalent of 167 lbs/A of total carbon. The same carbon sources were tested at half rate in combination with composted poultry manure (CPM) to balance the level of nitrogen to 268 lbs/A. During the ASD treatment soil was monitored measuring variations of pH, electrical conductivity (EC) and soil redox potential. All treatments reached anaerobic conditions despite the relatively low temperatures recorded during the experiment, and wheat middling reached the highest level of anaerobicity. After implementing ASD, green multi-leaf Salanova lettuce was planted to assess the effect of the treatments on crop performances and nutrient uptake. No phytotoxic effects were observed on lettuce after planting, and lettuce yield, dry biomass, and leaf area were not significantly affected by tested treatments. Following the lettuce crop in the spring of 2021 a fresh-market tomato crop was established on the same beds and experimental plots to evaluate the residual fertility effect of the sources of carbon tested for a longer period. Fruit yield and nutrient availability were monitored over time. Overall, the study demonstrated that ASD can be applied late in the fall, and that it is possible to use by-products of the Pennsylvania agri-food industry as C sources for ASD applications. Moreover, our study suggests that the fertilization plan for the crop following the ASD treatment should be adjusted considering the input of nutrients added to the soil with the carbon source and any supplementary organic amendment used for the application of the ASD treatments.

CABBAGE VARIETY TRIAL - THE RESULTS ARE IN
Spring and Fall Cabbage Cultivar Demonstration During COVID-19

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

Selecting which cultivar to grow is critical to successful vegetable production. When a cultivar is suited to an area and has high yield and quality for the market it is grown for, growers can make a profit. However, because numerous cultivars are commercially available, it can be difficult to select the best ones. In 2020-21 we evaluated up to 21 cultivars of spring and fall cabbage in western, central, and southeastern Pennsylvania to provide growers with up-to-date science-based information for successful, region-specific cultivar selection.

Methods: The study was conducted in central Pennsylvania at Pennsylvania State University's Russell E. Larson Research Center in Rock Springs, in southeastern Pennsylvania State University's Southeast Research and Extension Center in Manheim and western Pennsylvania at Yarnick's Farm.

Six- to eight-week-old transplants were planted in mid- to late March or early April for the spring crop and in early August to mid-August for the fall crop. The exact planting date varied by site. A plasticulture system consisting of black plastic mulch and drip irrigation was used at for the spring and fall crops in central and southeastern sites and the spring crop at the wester site. A system using raised beds without plastic was used for the fall crop at the western site. Plots consisted of 6 plants in a staggered double row with 1 ft in-row spacing and 6 ft between rows. Plants were provided with 1-1.5 acre-inches of water each week. Pests and fertility were managed following recommendations in the 2020/2021 Commercial Vegetable Production Recommendations guide and varied by conditions at each site.

Heads were harvested when they reach maturity: when heads were tight and had reached the desired size. At that time heads were categorized as marketable or unmarketable, counted, and weighed. We also determined maximum head and core height and width. In general, cultivars with no data collected in the fall were because they were not able to mature due to shorter days and cold weather. In the spring trial at the western site, non-harvested plots were due to wet conditions in the low part of the field.

A randomized complete block design was used with each cultivar replicated four times. Data was collected from 5 plants per cultivar per replication. Data were analyzed using the mixed procedure and means were separated using pdiff.

Results:

Western Pennsylvania
'Checkmate' was used as the standard at the Western site.
In the Fall of 2020, 'Checkmate' heads were significantly heavier than 'Ramada' heads and not different in mean weight than all other cultivars (Table 1). Mean head height and width were not significantly different between cultivars. 'Xtreme Vantage' heads had longer cores than 'Checkmate'. All other cultivars were not different than 'Checkmate'. 'Bravo' heads had wider mean core widths than 'Checkmate'. All other cultivars were not different than 'Checkmate'.

In the Spring of 2021, the mean head weight of 'Checkmate' was not different than all other cultivars. 'Gunma' had significantly shorter heads than 'Checkmate'. All other cultivars were not different than 'Checkmate'. 'Platinum Dynasty' had a smaller mean head width than 'Checkmate'. All other cultivars were not different than 'Checkmate'. The mean core heights of all cultivars were not different than 'Checkmate'. 'Bronco' had a wider mean core width than 'Checkmate'. All other cultivars were not different than 'Checkmate'.

Table 1. Yield and head characteristics of cabbage cultivars grown in Western Pennsylvania in the fall growing season of 2020 and the spring growing season of 2021.

	Fall 2020					Spring 2021				
Cultivar	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)
SSR-GC301	3.75 a*	15.12 a	17.23 a	6.92 bc	2.80 b	-	-	-	-	-
Checkmate	**3.37 ab**	**15.88 a**	**16.71 a**	**6.65 bc**	**2.28 b**	**4.35 a**	**16.74 a**	**16.73 ab**	**8.10 a**	**3.00 b**
Xtreme Vantage	3.09 a-c	16.11 a	17.30 a	8.10 a	2.85 ab	-	-	-	-	-
Tiara	3.07 a-c	15.71 a	15.18 a	6.71 bc	2.82 b	3.59 a	16.47 a	14.90 b	6.52 ab	2.99 b
Artost	3.02 a-c	14.74 a	15.56 a	5.84 c	2.88 ab	3.52 a	15.95 ab	15.21 b	6.51 ab	3.16 ab
Bravo	2.91 a-c	14.13 a	16.67 a	6.94 a-c	3.19 a	-	-	-	-	-
Farao	2.77 a-c	15.28 a	14.75 a	6.73 bc	2.85 ab	-	-	-	-	-
Platinum Dynasty	2.59 bc	14.75 a	14.83 a	7.04 ab	2.79 b	3.48 a	16.27 ab	15.07 b	5.89 b	3.21 ab
Ramada	2.06 c	13.80 a	14.75 a	6.12 bc	2.91 ab	-	-	-	-	-
Gunma	-	-	-	-	-	3.87 a	13.28 b	20.42 a	7.25 ab	3.10 b
Bajonet	-	-	-	-	-	3.86 a	16.94 a	15.77 b	7.76 a	3.08 b
Bronco	-	-	-	-	-	3.56 a	16.81 a	14.87 b	7.57 ab	3.58 a

*Values are means for individual heads; 'Checkmate' (bolded) is the standard to which all other cultivars were compared; Values in the green text within a column are significantly larger than 'Checkmate', values in the red text within a column are significantly smaller than 'Checkmate'; "-" indicates data was not collected from the cultivar during the corresponding season.

Central Pennsylvania

'Bravo' was used as the standard cultivar.

In the Fall of 2020, 'Capture' produced heavier heads than 'Bravo' (Table 2). 'Blue Vantage', 'Farao', 'Ramada', 'Thunderhead', 'SSR-GC-301', 'Gunma', and 'B-3269' produced lighter heads than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Checkmate' and 'Bajonet' produced taller heads and 'SSR-GC-301' shorter heads than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Platinum Dynasty', 'Blue Vantage', 'Farao', 'B-3269', 'Thunderhead', and 'Ramada' produced heads with smaller mean widths than 'Bravo'. All other cultivars were not different than 'Bravo'.

'Platinum Dynasty', 'Farao', 'Gunma', 'Ramada', 'Capture', 'Blue Vantage', 'SSR-GC-301', and 'Thunderhead' heads had shorter mean core heights than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Grand Vantage' and 'Bajonet' heads had a mean core width that was not different than 'Bravo'. All other cultivars had a mean core width that was smaller than 'Bravo'.

In the Spring of 2021, 'Thunderhead', 'Bronco', 'Capture', 'Artost', 'Zacapa', 'Farao', and 'Tiara' heads weighed less than 'Bravo' heads. All other cultivars were not different than 'Bravo'. 'Farao', 'Gumna', 'SRR-GC-301', 'Tiara', and 'Zacapa' heads were shorter than 'Bravo' heads. All other cultivars were not different than 'Bravo'. 'Thunderhead', 'Bronco', 'Ramada', 'Zacapa', 'Artost', 'Superstar', 'Farao', and 'Tiara' heads had smaller mean widths than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Superstar', 'Capture', and 'Tiara' heads had shorter mean cores than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Checkmate', 'SRR-GC-301', 'Thunderhead', 'Farao', and 'Tiara' heads had cores with smaller mean widths than 'Bravo'. All other cultivars were not different than 'Bravo'.

Table 2. Yield and head characteristics of cabbage cultivars grown in Central Pennsylvania in the fall growing season of 2020 and the spring growing season of 2021.

Cultivar	Fall 2020					Spring 2021				
	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)
Capture	5.27 a*	17.28 ab	18.67 ab	5.32 ce	3.43 ce	3.46 b-e	14.87 b-e	17.10 b-d	5.61 e	4.53 ae
Checkmate	4.80 ab	17.96 a	18.69 ab	6.07 ac	3.82 bd	3.62 a-e	15.41 a-e	16.89 b-e	7.83 ab	4.17 c-f
Superstar	4.68 a-c	17.03 ab	17.58 b-d	5.90 ad	3.73 bd	3.63 a-e	16.07 a-d	15.79 c-e	5.85 de	4.85 a
Bravo	**4.35 b-d**	**15.86 b-e**	**18.63 ab**	**6.78 ab**	**4.45 a**	**5.36 a**	**16.69 a-c**	**19.88 ab**	**7.29 ac**	**4.70 ab**
Grand Vantage	4.18 b-e	15.11 c-e	17.27 b-e	6.14 ac	4.15 ab	4.19 a-d	15.69 a-d	16.93 b-e	6.05 ce	4.73 ab
Bajonet	1.16 b-e	17.89 a	17.25 b-e	6.88 a	3.93 ac	4.64 a-c	16.97 ab	17.82 b-d	8.09 a	4.49 ae
Artost	3.99 c-f	16.33 bc	17.75 bc	5.83 bd	3.68 bd	3.10 c-e	14.49 c-e	15.83 c-e	6.24 ce	4.30 b-f
Platinum Dynasty	3.64 d-g	14.45 c-d	16.47 c-f	5.60 ce	3.86 bc	4.00 a-d	15.40 a-e	17.16 b-d	6.07 ce	4.52 ae
Tiara	3.57 d-h	15.93 b-e	17.01 b-e	5.79 bd	3.25 de	2.03 e	13.88 de	13.95 e	5.56 e	3.51 g
Blue Vantage	3.40 e-h	16.19 c-d	16.35 c-f	5.05 de	3.44 ce	4.04 a-d	15.55 a-d	17.71 b-d	7.05 ad	4.54 ae
Farao	3.35 f-h	15.43 c-e	16.17 c-f	5.38 ce	3.27 de	2.79 de	14.30 de	14.86 de	5.97 ce	3.84 fg
Ramada	3.08gh	14.84 de	15.14 f	5.37 ce	3.78 bd	3.83 a-e	15.35 b-e	16.44 c-e	6.52 be	4.83 a
Thunderhead	2.95 g-i	14.52 e	15.53 ef	4.58 e	3.45 ce	3.51 b-e	15.61 a-d	16.66 c-e	6.02 ce	4.10 ef
SSR-GC-301	2.91 g-i	12.72 f	18.36 b	4.60 e	3.59 bd	5.17 ab	14.07 de	21.30 a	6.42 be	4.14 d-f

Cultivar	Fall 2020					Spring 2021				
	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)
Gunma	2.78 hi	15.14 c-e	20.32 a	5.37 ce	3.55 cd	4.04 a-d	14.18 de	21.43 a	6.21 ce	4.48 ae
B-3269	2.17 i	15.90 b-e	15.91 d-f	5.98 ad	2.94 e	3.72 a-e	16.02 a-d	16.96 b-d	6.85 ae	4.66 ac
Botran	-	-	-	-	-	4.50 a-d	17.66 a	18.62 a-c	6.60 be	4.55 ae
Xtreme Vantage	-	-	-	-	-	4.40 a-d	16.03 a-d	18.73 a-c	6.70 be	4.59 ad
Bronco	-	-	-	-	-	3.50 b-e	15.63 a-d	16.50 c-e	6.69 be	4.89 a
Conqueror	-	-	-	-	-	4.27 a-d	15.98 a-d	17.85 b-d	6.50 be	4.77 ab
Zacapa	-	-	-	-	-	2.95 c-e	13.11 e	15.85 c-e	5.97 ce	4.77 ab

*Values are means for individual heads; 'Bravo' (bolded) is the standard to which all other cultivars were compared; Values in the green text within a column are significantly larger than 'Bravo', values in the red text within a column are significantly smaller than 'Bravo'; "-" indicates data was not collected from the cultivar during the corresponding season.

Southeastern Site
'Bravo' was used as the standard cultivar.

In the Spring of 2021, 'Conqueror', 'Tiara', and 'Checkmate' produced heavier heads than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Botran', 'Bajonet', 'Tiara', 'Blue Vantage', 'Superstar', 'Xtreme Vantage', 'Checkmate', 'Farao', and 'Conqueror' produced heavier heads than 'Bravo' while 'SRR-GC-301' and 'Gunma' produced lighter heads.

All other cultivars were not different than 'Bravo'. 'Bajonet' produced wider heads and 'Superstar', 'Tiara', 'Farao', and 'SRR-GC-301' narrower heads than 'Bravo'. All other cultivars were not different than 'Bravo'. 'Gunma' produced taller cores than 'Bravo'. 'Thunderhead', 'Farao', 'Platinum Dynasty', 'Artost', 'Bajonet', 'Tiara', 'Botran', 'Ramada', 'Grand Vantage', 'Blue Vantage', 'Bronco', 'B-3269', 'Zacapa', and 'Superstar' produced heads with cores that were shorter than 'Bravo'. All other cultivars were not different than 'Bravo'. All cultivars were not different than 'Bravo' in terms of mean core width.

Table 3. Yield and head characteristics of cabbage cultivars grown in Southeastern Pennsylvania in the spring growing season of 2021.

Cultivar	Spring 2021				
	Mean marketable weight (lb)	Mean head height (cm)	Mean head width (cm)	Mean core height (cm)	Mean core width (cm)
Conqueror	3.16 a*	14.93 b-d	15.60 cd	6.45 d-g	3.07 a-c
Tiara	3.16 a	15.35 ab	14.73 e-i	6.10 fg	2.91 a-c
Checkmate	3.16 a	14.99 b-d	15.39 c-e	7.00 b-f	3.00 a-c
Botran	3.09 ab	15.94 a	14.60 f-j	6.62 c-g	2.90 a-c
Xtreme Vantage	3.05 a-c	15.05 b-d	15.15 c-f	7.14 b-e	3.16 a-c
Farao	3.04 a-c	14.97 b-d	14.80 e-h	6.02 g	2.95 a-c
Artost	3.02 a-c	14.59 c-e	14.77 e-h	6.57 c-g	3.21 ab
SRR-GC-301	3.01 a-c	12.99 gh	16.47 b	4.79 h	2.88 bc
Platinum Dynasty	2.95 a-c	14.45 de	14.78 e-h	7.73 ab	3.31 ab
Blue Vantage	2.95 a-c	15.26 b	14.12 h-k	6.32 e-g	3.23 ab
Bronco	2.94 a-b	14.55 c-e	14.02 i-k	7.12 b-e	3.29 ab
Bajonet	2.91 a-c	15.55 ab	14.75 e-i	8.60 a	3.12 a-c
Capture	2.91 a-c	14.07 ef	15.82 bc	7.48 bc	3.08 a-c
Superstar	2.90 a-c	15.09 bc	13.64 k	6.11 fg	3.08 a-c
Ramada	2.90 a-c	14.05 ef	14.25 g-k	7.37 b-d	3.01 a-c
Gunma	2.88 b-d	12.75 h	18.91 a	7.80 ab	3.01 a-c
Bravo	**2.84 b-d**	**14.07 ef**	**15.76 bc**	**7.22 b-e**	**3.16 a-c**
Zacapa	2.81 cd	14.00 ef	13.87 jk	7.03 b-f	3.26 ab
Thunderhead	2.81 cd	14.03 ef	14.89 d-g	6.94 b-g	2.74 c
Grand Vantage	2.80 cd	13.54 gf	14.18 g-k	7.31 b-d	3.32 ab
B-3269	2.64 d	14.22 e	13.93 jk	7.42 b-d	3.28ab

*Values are means for individual heads; 'Bravo' (bolded) is the standard to which all other cultivars were compared; Values in the green text within a column are significantly larger than 'Bravo', values in the red text within a column are significantly smaller than 'Bravo'; "-" indicates the cultivar was not evaluated during the corresponding season.

Western Site: Farmers looking for a fall cabbage cultivar that produces heads that are not different in weight than 'Checkmate' can select any of the cultivars grown except 'Ramada'. 'Ramada' may produce lighter heads than 'Checkmate'. Farmers can expect similar head sizes from all the cultivars evaluated as they had head heights and widths that were not different than 'Checkmate'. We observed some differences from 'Checkmate' in core height and width. When long cores are desired, 'Xtreme Vantage' may be selected. When wide cores are preferred, consider 'Bravo'.

For spring cabbage, farmers looking for a cultivar that produces heads that are not different in weight than 'Checkmate' can select any of the ones evaluated. 'Gunma' is an option for cabbage that is shorter than 'Checkmate' and 'Platinum Dynasty' for skinnier heads. The cores of all the cabbage cultivars evaluated were not different than 'Checkmate' which makes all the cultivars evaluated good options for standard-sized cores.

Central Site: Farmers wanting to grow fall cabbage heads that are heavier than 'Bravo' can consider 'Capture'. When a lighter weight head is desired 'Blue Vantage', 'Farao', 'Ramada', 'Thunderhead', 'SSR-GC-301', 'Gunma', and 'B-3269' are options. 'Checkmate' and 'Bajonet' are options when heads taller than 'Bravo' are desired and 'SSR-GC-301' may be used when shorter ones are preferred. 'Platinum Dynasty', 'Blue Vantage', 'Farao', 'B-3269', 'Thunderhead', and 'Ramada' produced heads that are narrower than 'Bravo' and can be considered when this trait is desired. When a

shorter core than 'Bravo' is preferred, consider 'Platinum Dynasty', 'Farao', 'Gunma', 'Ramada', 'Capture', 'Blue Vantage', 'SSR-GC-301', and 'Thunderhead'. 'Bravo', 'Grand Vantage', and 'Bajonet' had the widest cores. If narrower cores are desired, consider any of the other cultivars evaluated.

For spring cabbage, 'Thunderhead', 'Bronco', 'Capture', 'Artost', 'Zacapa', 'Farao', and 'Tiara' are possibilities when heads that are lighter than 'Bravo' are desired. 'Farao', 'Zacapa', and 'Tiara' are options when heads that are shorter and narrower than 'Bravo' are desired. When heads that are just narrower are preferred, 'Thunderhead', 'Bronco', 'Ramada', 'Artost', and 'Superstar' are options. When heads that are just shorter are preferred, 'Gunma', and 'SRR-GC-301' can be considered. 'Tiara' heads have overall smaller cores than 'Bravo'. When just shorter cores are desired, 'Superstar' and 'Capture' are options. When just narrower cores are preferred, 'Checkmate', 'SRR-GC-301', 'Thunderhead', and 'Farao' are possibilities.

Southeastern Sites: Farmers wanting to grow spring cabbage heads heavier than 'Bravo' can consider 'Conqueror', 'Tiara', and 'Checkmate'. 'Bajonet' is an option for heads that are taller and wider than 'Bravo' and 'SRR-GC-301' for heads that are shorter and narrower. Options for heads that are just taller than 'Bravo' are 'Botran', 'Tiara', 'Blue Vantage', 'Superstar', 'Xtreme Vantage', 'Checkmate', 'Farao', and 'Conqueror'. 'Gunma' is an option when heads that are just shorter than 'Bravo' are desired. 'Superstar', 'Tiara', and 'Farao' are possibilities when heads that are just narrower than 'Bravo' are preferred. For heads with core heights that are longer than 'Bravo', consider 'Gunma'. 'Thunderhead', 'Farao', 'Platinum Dynasty', 'Artost', 'Bajonet', 'Tiara', 'Botran', 'Ramada', 'Grand Vantage', 'Blue

Vantage', 'Bronco', B-3269, 'Zacapa', and 'Superstar' are options when shorter cores than 'Bravo' are preferred. The core width of all cultivars was not different than 'Bravo'.

Statewide Considerations

Appearance, days to harvest, and shape are also considerations when selecting cultivars in addition to the data we collected. Click the link to this table for more information about the cultivars evaluated in this evaluation: Cabbage Cultivars Evaluated

Acknowledgements: In addition to funding from the PVMRP, this work would not have been possible without the efforts of the PSU Hort Farm Crew, especially Chris Sánchez and Austin Kirt. Additionally, Alan Bauman and Devan Stoner were undergraduate students whose hard work contributed to the success of this project. We also thank Dan, Lynette, and Joey Yarnick from Yarnick's Farm in Indiana County for hosting the western site.

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SAFFRON – HOW TO GROW THE MOST EXPENSIVE HERB IN THE WORLD

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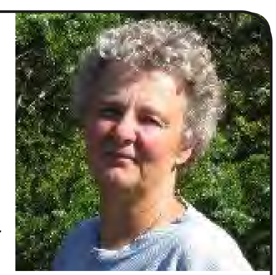
Fig. 1. Saffron flower. Arrow points to the stigmas.

Saffron, a culinary spice and medicinal/cosmetic product, is derived from the stigmas of a fall-blooming crocus (Crocus sativus L.) (Fig. 1). In 2020 the global saffron market was valued at $375 million and the US was among the top ten saffron importers, bringing in 78 metric tons valued at $14.8 million. Saffron offers new revenue opportunities for small, diversified farmers. It is adapted to arid climates but thrives in moist, temperate regions and can be grown in over 75% of the US, including the Northeast and Mid-Atlantic states. Pennsylvania Dutch growers have been cultivating saffron for over 300 years, but mostly for their personal use. Research at UVM has led to expanded saffron cultivation among commercial growers across the US and Canada. At a retail price of over $20/gram, this crop could net $100,000/acre. It is an emerging crop, suitable for a wide range of growers, particularly vegetable and nursery/floriculture producers.

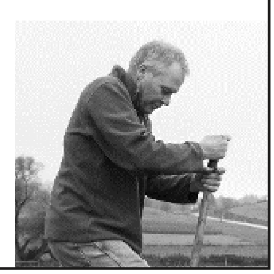
UVM researchers have shown that saffron can be grown successfully in the field and in high tunnels in the colder regions of the Northeast. Growers and researchers are continuing to learn new information about how to cultivate saffron under a broad range of climatic and agricultural conditions in North America. In this presentation, a UVM researcher and a Pennsylvania farmer who has been growing saffron for several years will describe the basic steps involved with growing, harvesting and processing saffron in the Northeast.

In many ways, the lifecycle of saffron is ideal for vegetable growers. It is a fall-blooming crocus that is planted in August/September, and blooms in October-November (Fig. 2). Though harvesting and separating saffron flowers is labor intensive, growers can integrate this non-traditional crop into their rotation because the high demands of con-

Dr. Margaret Skinner is a Research Professor at the Univ. of Vermont, where she has worked for 38 years, conducting research on management of a wide array of insect pests in forests, vegetables and greenhouse ornamentals. In 2017 she co-founded the UVM North American Center for Saffron Research & Development, and has been involved with assessing the potential of saffron as a high value crop for small, diversified farmers. Her current work involves supporting the emerging North American saffron industry through applied research on production, post-harvest handling and developing markets for locally grown saffron. She has also collaborated with solar companies to investigate the potential of growing saffron in solar arrays.



Scott Case and his wife Eda own and operate Patchwork Farm in Centre County, PA. They have run this diversified business since 1991, which includes a greenhouse operation, field grown cut flowers, saffron and organic produce. He started growing saffron 3 years ago to expand the scope of his production with high-value specialty crops. Scott is the chair of the PA Sustainable Agriculture organization. He joined the board to help the next generation of farmers succeed.



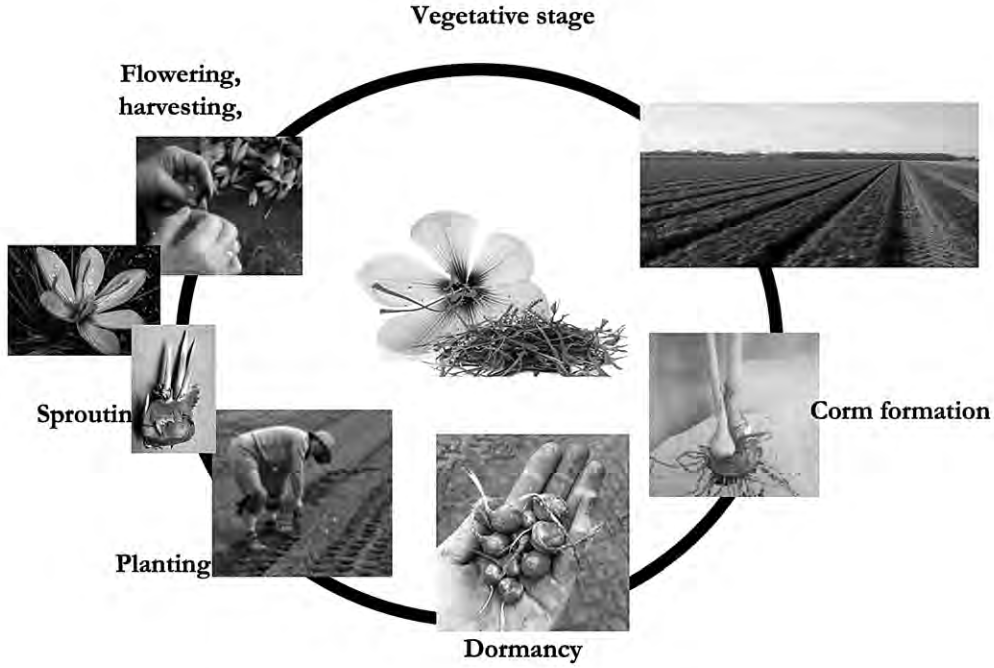


Fig. 2. Life cycle of saffron. Corms are usually planted in August or September. The corms begin to root soon after planting in the fall. Within 30-40 days after planting, the corm sends up leaf sprouts and then flowers. Unlike the spring-blooming crocus species, after flowering, the leaves of the saffron crocus remain green all winter and spring. When temperatures rise in spring, secondary corms form above the parent corm. The secondary corms become the source of flowers in the fall. When the leaves of the parent corm turn brown, that is a sign it has died, and the secondary corms are dormant. These corms remain dormant until the fall when they root, leaf out and flower. Though technically saffron isn't a perennial crop, it is treated like one because the original saffron bed remains in place for 3-6 years, each year increasing in density. NOTE: As with all plants, the life cycle of saffron varies, depending on

ventional field crops have waned at the time when saffron blooms. Once established, a saffron bed can continue to produce good flower yields for 3-6 years without additional inputs. The labor demands for saffron are likely not more than for high-tunnel tomatoes, while the revenues can be significantly more. For example, many US saffron growers are selling their saffron for $20-50/gram, which is equivalent to around $9,000-22,000/pound. Mechanical saffron harvesting/processing equipment is under development to reduce labor expenses. In a good year, a grower could harvest around 5-12 lb/acre within 3 years of establishing their saffron beds. Skeptics question the marketability of saffron, but given the strong locovore movement, US saffron could compete for a share of this market.

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

Want to learn more about saffron? Subscribe to *"Saffronnet"*, UVM's email listserv. There are over 800 avid saffron-growing subscribers from across the US and worldwide.

Send an email to Margaret Skinner, mskinner@uvm.edu and she will add you to the list.

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PLANT-MEDIATED SYSTEMS IN HIGH TUNNELS

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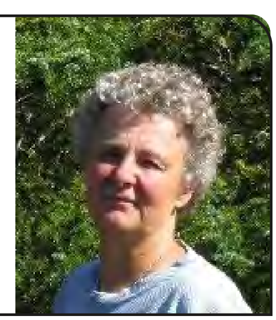
These days most vegetable growers in the Northeast and Mid-Atlantic states have one or more high tunnels—rudimentary hoop houses covered with one or two layers of plastic, vented with roll-up sides for cooling in warm weather, and often lacking electricity or heating. These have become essential for producing vegetables as weather conditions become more extreme and less predictable. They allow growers to extend their vegetable growing season, protect their crops from adverse weather and supply crops early to maximize on the market. Plant production is a balancing act. Growers must create conditions that favor the crop, but these often encourage pest survival. High tunnels present unique pest management challenges, and effective Integrated Pest Management (IPM) strategies in these structures are lacking. Scientists from the Univ. of Vermont have assessed several plant-mediated systems to reduce pest populations and crop damage. This presentation describes several of these systems that growers could use to manage their pest problems while supporting natural enemy populations within high tunnels.

What are Plant-mediated IPM Systems? These are plant-based systems used for an assortment of IPM tactics. There are four basic applications for these systems:

1. An effective scouting or early pest detection tool (trap or indicator plants).
2. A habitat or food source to support natural enemy populations (habitat/insectary plants).
3. A mass-rearing system for natural enemies in the growing area (banker plants).
4. The combination of multiple strategies to attract the pest and natural enemies, **sustain natural enemies or fungi, and kill or suppress the pest population (guardian plants).**

How do they work? Trap or indicator plants are those known to be particularly attractive to various pest species. These plants lure the pest out of the crop, and can be used as an early detection tool. Hero yellow marigolds are an example. When in flower, marigolds attract thrips out of the crop, and have been found to detect the pest earlier than yellow sticky cards. Growers can reduce the time required for scouting by checking the marigolds. **Habitat or insectary plants** are those that supply a suitable environment for supporting natural enemy populations. Some are flowering plants that produce pollen or nectar as an alternate food source for beneficial insects in the absence of prey. Others provide shelter or habitats in which the natural enemies can reproduce or complete development. Alyssum is one example. When in flower, this plant attracts high numbers of natural enemies that feed on the pollen. As the populations of beneficials increase, they move out into the crop in search of prey. **Banker plants** are those that support populations of an alternate non-pest insect species on which natural enemies are produced. These systems can provide a sustained supply of natural enemies in the high tunnel. **Guardian plants** combine multiple functions into one plant. They can attract the pest but also serve as a suitable habitat for supporting natural enemies. This ensures a continual supply of natural enemies while also keeping pest populations low.

Dr. Margaret Skinner is a Research Professor and Extension Entomologist at the Univ. of Vermont, Entomology Research Lab, where she has worked for 38 years, conducting research on IPM for insect pests in forests, vegetables and greenhouse ornamentals. She works on devising strategies to maximize the potential of insect-killing fungi and plant-mediated systems. As UVM's Extension Entomologist she assists commercial growers and homeowners with pest id and IPM.



Which Plant-mediated System is Best? Like everything, **it all depends**… When considering which plant-mediated system to use, a grower needs to factor in the amount of time it requires. However, the key to successful IPM, especially when using biological control demands a proactive approach. Once a pest population explodes, it is very difficult, without chemical pesticides, to bring it back down to a manageable level. That is why scouting is critical. Before planting a seed in the soil, a grower should develop a regular scouting program to ensure that pests are detected early. This should include taking data that can be reviewed over time within or between years. Using **trap/indicator plants** can be a cost-effective way to monitor populations of both the pest and beneficial insects. Ideally plants should be placed in the high tunnels before the crop is added. This allowed resident pests to be attracted to them rather than the crop. If the pest population builds up too high on these plants, they can be bagged up and destroyed before the pests move out into to the crop. **Habitat plants** are also a simple and inexpensive way to support natural enemy and pollinator populations, and help get them established early. 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 there's a food source if there are no pests in the crop. Many growers now routinely plant clumps of a combination of alyssum, marigolds and green beans at the ends of each row of tomatoes. The beans attract spider mites, and natural enemies are released there to manage them. Natural enemies and pollinators from outside the high tunnel are also attracted to these plants adding a free source of beneficials. Some growers swear by **banker plants** as a low-cost way to stock the high tunnel with biocontrol agents. They require ongoing attention to maintain clean stock cultures, but once a system is set up, they can provide fresh biocontrols throughout the season, eliminating the need for frequent reordering from commercial biocontrol suppliers. **Guardian plants** bring the benefits of each system together into one. The marigold guardian plant is used to manage western flower thrips. After the marigold begins to flower, it is put into the growing area, and a slow-release sachet of predatory mites is added. The mites feed on thrips in the flowers and foliage and pollen in the absence of prey. A granular or drench treatment of the insect-killing fungus is added to the soil to target the pupal stage of the insect. Once set up, these guardian plants provide sustained management of thrips for up to 12 weeks.

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PIGWEED IDENTIFICATION, HERBICIDE RESISTANCE SCREENING, AND EFFECTIVE MANAGEMENT STRATEGIES

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Introduction: Pigweed species (genus Amaranthus) are significant weedy pests in both agronomic and horticultural production systems. Results from surveys conducted by the Weed Science Society of America (WSSA) in 2019 and 2020 found that Palmer amaranth (*Amaranthus palmeri*), waterhemp (*Amaranthus tuberculatus*), smooth pigweed (*Amaranthus hybridus*), redroot pigweed (*Amaranthus retroflexus*), Powell amaranth (*Amaranthus powellii)* and others were some of the most common and troublesome weeds of corn, alfalfa, cole crops, cucurbits and fruiting veg, among other commodities (https://wssa.net/wssa/weed/surveys/). In addition to being directly competitive, pigweed species have developed resistance to multiple herbicide active ingredients, which can limit control options (www.weedscience.org). For example, Palmer amaranth and waterhemp, two growing problems in NY and the region, have populations in the US that are resistant to at least five different herbicide classes. While it may be convenient to lump all Amaranthus together when making management decisions, proper identification is important to develop the most effective management programs; this is especially true when herbicide resistance is involved and/or a novel species is spreading.

Pigweed identification: Identifying pigweeds can be especially difficult, particularly when looking at young plants. The evaluation of single traits (i.e. leaf shape, inflorescence) is not likely to result in a positive identification; consequently, multiple features should be examined. Below is a description of some commonly occurring pigweeds to assist with discrimination among the species.

PALMER AMARANTH (*Amaranthus palmeri)*:
Nativity: Southwest US but found throughout much of the lower 48 states.
Leaves: Diamond-shaped, sometimes with a V-shaped watermark on the leaf blade. Petioles on lower leaves are AS LONG OR LONGER than the leaf blades. Plant may resemble a poinsettia when viewed from above. Leaf surfaces lack hairs.
Stems: Red or green or striped in color and lacking hairs (smooth).
Height: Very tall, can grow to 8 to 10 feet. Plants can grow INCHES PER DAY under optimum conditions.
Flowers: Male and female flowers are formed on branched, terminal spikes (which can be 2 to 3 feet in length) on SEPARATE plants. Male flower structures are soft and shed yellow pollen. Female flower structures produce stiff and sharp bracts and set seed.

WATERHEMP (*Amaranthus tuberculatus*):
Nativity: Midwestern US but found throughout much of the lower 48 states.
Leaves: Long and narrow and sometimes oval. Often darker green and shiny/waxy in appearance. Hairless. Petioles are shorter than the blade.
Stems: Red or green or striped in color and lacking hairs (smooth).
Height: Very tall up to 8 to 10 feet.

Lynn Sosnoskie joined Cornell AgriTech in September 2019 as an Assistant Professor of Weed Ecology and Management in Specialty Crops, which includes tree and vine crops in addition to fresh and processing vegetables. A native of Pennsylvania, she earned a B.Sc. in Biology from Lebanon Valley College, a M.Sc. in Plant Pathology at the University of Delaware and a Ph.D. in Weed Science at Ohio State. Prior to coming to Cornell, Lynn worked as a research scientist at the University of Georgia, the University of California – Davis, and Washington State University. Her work has focused on a variety of crops (almonds, cotton, melons, peppers, pistachios, tomatoes, walnuts and wheat) and a variety of weeds (field bindweed and glyphosate resistant Palmer amaranth, hairy fleabane, horseweed, and junglerice). She was most recently employed by the University of California as a Farm Advisor working with agronomic crops in the Central Valley, which is California's agricultural hub.

Flowers: Male and female flowers are primarily formed on terminal spikes on SEPARATE plants. Male flower structures shed yellow pollen. Female flower structures set seed. Unlike Palmer amaranth, waterhemp's flowers are not as tightly clustered on the inflorescence; female flowers do not produce sharp bracts.

REDROOT PIGWEED *(Amaranthus retroflexus)*:
Nativity: Native to and widespread in the lower 48 states.
Leaves: Rounded at first, becoming more pointed with age. Edges have wavy margins. Veins are prominent on underside. Petiole shorter than leaf blade. Leaves can be hairy underneath or at least along the veins.
Stems: VERY HAIRY, especially closest to newest growth.
Height: 3 to 5 feet in height.

Flowers: Male and female flowers are held in terminal inflorescences on the SAME plant. Branches on the flower spikes are short and thick/compact.

SMOOTH PIGWEED *(Amaranthus hybridus)*:
Nativity: Native to and widespread in the lower 48 states.
Leaves: Egg- to oval-shaped becoming more pointed with age. Edges have wavy margins. Petiole shorter than leaf blade.
Stems: Fine hairs throughout, especially closest to new growth.
Height: 3 to 5 feet in height.
Flowers: Male and female flowers are held in terminal inflorescences on the SAME plant. Branches are longer and thinner than redroot pigweed. Very difficult to distinguish from redroot pigweed until flowering.

POWELL AMARANTH *(Amaranthus powellii)*:
Nativity: Native to and widespread in the lower 48 states.
Leaves: Rounded at first, becoming more pointed with age. Edges have wavy margins. Petiole shorter than leaf blade.
Stems: Fine hairs throughout, especially closest to new growth.
Height: 3 to 5 feet in height.
Flowers: Male and female flowers are held in terminal inflorescences on the SAME plant. Branches are longer than those of redroot pigweed and may appear to have bracts not unlike Palmer amaranth (but which aren't stiff and sharp). Can be confused with smooth and redroot pigweed, especially at seedling stages. Powell amaranth could be confused with Palmer amaranth at larger growth stages. Look at the stems, which are slightly hairy, as opposed to smooth for Palmer amaranth. The length of the petioles will also be shorter than the leaf blade. If flowering, look for the presence of male and female flowers on the same plant (palmer amaranth produces separate male and female plants).

Herbicide resistance: While herbicide resistance is typically assumed to be a critical threat to agronomic systems, it can and does occur in specialty crops. Pigweeds are a significant threat with respect to the development of resistance; 11 species worldwide are resistant to one or more herbicides/herbicide classes (hundreds of separate cases have occurred worldwide). In the Mid-Atlantic and Northeastern US, in vegetable systems, there are confirmed occurrences or credible reports of ALS-inhibitor-resistant purple pigweed (*Amaranthus blitum*) and smooth pigweed, ALS- and PS II-inhibitor-resistant redroot pigweed, and glyphosate-resistant Palmer amaranth. Resistance to linuron in Powell amaranth has also been confirmed. Best management practices to control weeds and limit the development of herbicide resistance include: frequent scouting, , planting into weed free fields, using physical and cultural suppression strategies, applying herbicides (including tank mixtures) at recommended rates and at the proper timing, rotating crops, diversifying strategies and practices as much as possible, and cleaning planting, cultivation, and harvest equipment between fields. Pigweeds are, and will likely remain, problems across all production systems.

HIGH HEAT AND VEGETABLE PRODUCTION

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Climate change has the potential to affect fruit and vegetable production as temperatures increase. Climate data from the region has shown a steady increase in average temperatures over the last 100 years with average night temperatures in summer months increasing the most. Record high temperatures have occurred throughout the past decade and many vegetable crops have had losses due to the heat. Providing adequate moisture through irrigation is critical in high heat periods. However, maintaining soil moisture cannot completely compensate for extreme heat.

The plant temperature at which tissue dies is around 115°F. Normally, plant temperature is just above air temperature. However, plant temperature can rise to a critical level under certain conditions. Plants have 3 major ways in which they dissipate excess heat: 1) long-wave radiation, 2) heat convection into the air and 3) transpiration.

A critical factor is transpiration. If transpiration is interrupted by stomatal closure due to water stress, inadequate water uptake, injury, vascular system plugging or other factors, a major cooling mechanism is lost. Without transpiration, the only way that plants can lose heat is by heat radiation back into the air or wind cooling. Under high temperatures, radiated heat builds up in the atmosphere around leaves, limiting further heat dissipation.

Dry soil conditions start a process that can also lead to excess heating in plants. In dry soils, roots produce Abscisic Acid (ABA). This is transported to leaves and signals to stomate guard cells to close. As stomates close, transpiration is reduced. Without water available for transpiration, plants cannot dissipate much of the heat in their tissues. This will cause internal leaf temperatures to rise.

Vegetables can dissipate a large amount of heat if they are functioning normally. However, in extreme temperatures (high 90s or 100s) there is a large increase the water vapor pressure deficient (dryness of the air). Rapid water loss from the plant in these conditions causes leaf stomates to close, again limiting cooling, and spiking leaf temperatures, potentially to critical levels causing damage or tissue death.

Very hot, dry winds are a major factor in heat buildup in plants. Such conditions cause rapid water loss because leaves will be losing water more quickly than roots can take up water, leading to heat injury. Therefore, heat damage is most prevalent in hot, sunny, windy days from 11 a.m. to 4 p.m. when transpiration has been reduced. As the plants close stomates to reduce water loss, leaf temperatures will rise even more. In addition, wind can decrease leaf boundary layer resistance to water movement and cause quick dehydration. Wind can also carry large amounts of advected heat.

Photosynthesis rapidly decreases above 94°F, so high temperatures will limit yields in many vegetables and fruits. While daytime temperatures can cause major heat related problems in plants, high night temperatures can have great effects on vegetables, especially fruiting vegetables. Hot night temperatures (nights above 75) will lead to greater cell respiration. This limits the amount of sugars and other storage products that can go into fruits and developing seeds.

High temperatures also can cause increased developmental disorders in fruiting vegetables. A good example is with

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pollen production in beans. As night temperatures increase, pollen production decreases leading to reduced fruit set, reduced seed set, smaller pods, and split sets. Most fruiting vegetables will abort flowers and fruits under high temperatures.

Heat injury in plants includes scalding and scorching of leaves and stems, sunburn on fruits and stems, leaf drop, rapid leaf death, reduction in growth, and lower yields. Wilting is the major sign of water loss which can lead to heat damage. Plants often will drop leaves or, in severe cases, will "dry in place" where death is so rapid, abscission layers have not had time to form.

On black plastic mulch, surface temperatures can exceed 150°F. This heat can be radiated and reflected onto vegetables causing tremendous heat loading. This is particularly a problem in young plants that have limited shading of the plastic. This can cause heat lesions just above the plastic. Heat lesions are usually first seen on the south or south-west side of stems. High bed temperatures under plastic mulch can also lead to reduced root function limiting nutrient uptake. This can lead to increased fruit disorders such as white tissue, yellow shoulders, and blotchy ripening in tomato fruits.

High heat and associated water uptake issues will cause heat stress problems. As heat stress becomes more severe a series of event occurs in plants starting with a decrease in photosynthesis and increase in respiration. As stress increases, photosynthesis shuts down due to the closure of stomates which slows or stops $CO2$ capture and increases photorespiration. This will cause growth inhibition. There will be a major slow-down in transpiration leading to reduced plant cooling and internal temperature increase. At the cellular level, as stress becomes more severe there will be membrane integrity loss, cell membrane leakage and protein breakdown. Toxins generated through cell membrane releases will cause damage to cellular processes. Finally, if stress is severe enough there can be plant starvation through rapid use of food reserves, inefficient food use, and inability to call on reserves when and where needed.

Another negative side effect of reduced plant photosynthate production and lower plant food reserves during heat stress is a reduction in the production of defensive chemicals in the plant leading to increased disease and insect vulnerability.

The major method to reduce heat stress is by meeting evapotranspiration demand with irrigation. Use of overhead watering, sprinkling, and misting can reduce of tissue temperature and lessen water vapor pressure deficit. Certain mulches can also help greatly. You can increase reflection and dissipation of radiative heat using reflective mulches or use low density, organic mulches such as straw to reduce surface radiation and conserve moisture.

Shading for Heat Stress Mitigation

Artificial shading is a strategy that can be used mitigate heat stress. Commonly, shade cloth or netting is used for this purpose. This netting comes in black, green, white, and reflective aluminum colors and is commonly used at the 20-30% shade levels. Shading is applied during the hottest periods or periods when the plant is most sensitive to heat (such as tomato fruit development). Research at the University of Maryland by Jerry Brust showed that shading tomatoes during fruiting can improve fruit quality and reduce culls. Research at the University of Georgia on peppers showed similar results with improvement in the number of marketable fruits. Kansas research showed that lettuce production was improved where white shade cloth was used.

University of Delaware research with shading of strawberries for summer production showed mixed effects with shading benefiting in some years but not in others. In 2018 and 2019 University of Delaware vegetable researchers studied the effect of shade cloth on tomato and pepper marketable yield. Treatments were no shade, 30% black, 30% Aluminet, 30% red, 22% white, 40% white. In 2018 shade treatment did not have a significant effect on pepper quality or marketable yield. In contrast, in 2019 shade treatments, especially 30% black, shaded plots produced more marketable peppers than the unshaded plots. Yield of marketable first harvest (early Aug) for 30% black was 18x higher than unshaded. Yield of marketable second harvest (Sep) was 2x unshaded. Shade did not reduce internal white tissue in tomatoes to the point of achieving marketability in the 2018 or 2019 trial. Lettuce trials were conducted with no shade, 30% black, 30% Aluminet, 30% red, 30% blue, 22% white, and 40% white. Shade cloth reduced soil temperatures by 3 °C. Shaded lettuce treatments had reduced bitterness in both the 2018 and 2019 trials. For lettuce the combination of a heat tolerant variety with shade had the greatest effect on reducing bitterness.

To summarize, there is good evidence that 30% black shade cloth applied during the hottest time period (early June through early August) improves bell pepper yield and quality. There is also good evidence that shade cloth reduces bitterness in lettuce, especially when used with a heat tolerant variety. There is some evidence that 30% black shade cloth increases tomato quality.

As you make your variety selections for 2022 you might want to consider trying a few heat tolerant varieties. Some vegetables, such as eggplant, okra and sweet potatoes, are inherently very heat tolerant. In other crops there are notable differences in heat tolerance between varieties and some varieties have been selected particularly for heat tolerance. In Delaware we can experience temperatures that exceed what is ideal for certain vegetables, especially from late June through August. Try targeting heat tolerant varieties in the planting window that is most likely to be exposed to high temperatures in the crop's heat susceptible growth stage.

Snap Beans
In the early flowering stage, snap beans are susceptible to yield and quality loss from high night temperatures (above 70 °F). High night temperatures damage pollen in developing buds and prevent pollen release when the flowers open. As a result, seeds do not set. Pods with low seed set may drop off the plant or mature with only a few seeds, resulting in deformed, unmarketable pods. Over the past three years I have evaluated snap bean varieties for heat tolerance in Delaware and the following varieties maintain yield and quality during heat events: PV 857, Annihilator and Dominator (round podded) and Usambara (flat podded).

Unstressed or heat tolerant bean plants produce full-length pods with even seed development (left). Moderate heat stress can result in pods with some missing seeds (center). Bean plants affected by heat stress produce shorter, deformed, unmarketable pods (right).

Tomatoes
High temperatures can interrupt fruit set in tomatoes, again by interfering with pollination. Even in varieties with good "heat set", high temperatures can cause fruit quality problems like yellow shoulders and internal white tissue. Gordon Johnson conducted a heat stressed tomato variety trial in 2019. The varieties Red Bounty and STM2255 maintained the best yield and quality under heat stress in that trial.

Lettuce
Lettuce bolts and becomes bitter when exposed to high temperatures. Some varieties are slower to bolt but may still develop a bitter flavor when exposed to heat. Based trials done in 2012, 2018 and 2019 the following varieties resist bolting and are slow to develop a bitter flavor (All lettuce will eventually bolt and turn bitter): Butterhead: Salanova® Green Butter, Salanova® Red Butter, Skyphos; Leaf: Starfighter; Romaine: Dov and Arroyo.

Sweet Corn
In trials conducted in 2019 the following sweet corn varieties performed well under heat stress conditions for a mid-July harvest (planted on May 21): Bicolor Supersweet: Affection and Nirvana; White Supersweet: Xtra Tender 378A and XTH 3174; White SE: Whiteout and Mattapoisett

Broccoli
Based on research done by Thomas Björkman and Karen Pearson at Cornell University, broccoli is most susceptible to heat stress (temps > 90 °F) in the early head formation stage. The susceptible window includes the 10 days prior to when a tiny crown of 5-10 mm is visible at the center of the plant. Once the crown is visible, the most susceptible stage has passed. Prolonged heat exposure in the susceptible window results in uneven head development, leafy heads and variable bead size. Delaware variety trials found that varieties that are more tolerant of heat stress include Eastern Crown and Millennium.

Brussels Sprouts
In trials done by Gordon Johnson in 2018 and 2019 Hestia, Marte, and Dagan Brussels sprouts varieties produced well under southern Delaware's stressful growing conditions.

COVER CROPS - A BIG PART OF SUCCESSFUL VEGETABLE PRODUCTION

Art King – Harvest Valley Farms

We have always used rye as a cover crop when we could, but about 8 years ago we started using additional cover crops with great success. Sudan grass has become one of our favorites. The effects of Sudan on soils are amazing. It is a summer cover crop and needs to be planted in 65-degree soils. When the grass reaches 4 to 7 feet high it should be mowed so that the seed heads do not mature. After it is mowed, the root mass increases by nearly 50% and goes 100% deeper into the soil, breaking up hard pan. It is excellent at controlling some weeds, such as Canada thistle. Sudan produces "allele pathic" compounds that act as a weed suppressor for many common weeds. But one of the most important aspects is the volume of biomass it creates before it frosts kills in the fall, about 5,000 lb. per acre can be expected. As a wise farmer friend of mine once told me, "You can bring in manure or compost all you want, but you can never match to volume of a good cover crop". Another great aspect of Sudan is how it leaves very little debris by the spring and is easily plowed under.

Another one that has become a favorite cover crop of ours is oats and peas mixture. If we have crops that we are picking past the middle of October, we can't get the rye established well enough to hold the soil over winter. (Keep in mind we are farming on slopes usually) So we leave the plastic down over winter and pick it up as soon as we can get into the field in March. Since oats and peas love cold soils, they grow great then. The peas add nitrogen to the soil and the oats grow like crazy. We flail mow the crop and plow in mid-June or so. Or, we can drill in Sudan at that time as well for a double cover crop.

Things to keep in mind with cover crops

Whatever you do, don't try to plow down a 5-foot-high cover crop and then try to lay plastic. It's nearly impossible to get the crop chopped up enough to make a decent raised bad.

A good cover crop increases worm populations. This is very beneficial in most crops, since what comes out the back of a worm is perfect plant food. But this is a big problem when planting onion transplants, as earthworms will pull the slightly dried up tips of plants under the plastic. If you use fresh green plants, properly planted, it's ok.

You may need to fertilize cover crops if the soil is worn out. You will know quickly if that is the case because the plants will be yellow.

You can increase the stand of rye if is broadcasted heavily in late August. It is possible to double the amount of biomass in good soils this way. It's likely it will get blown down in heavy rain when it is mature, so mow early.

My 6' son, Dave, in front of a good crop of Sudan

Art King operates Harvest Valley Farms with his son David and his brother Larry in Valencia, PA, just north of Pittsburgh. Growing over 100 varieties of small fruits and vegetables on 160 acres, they also have a 530 member CSA, sell at 3 farmers markets, a Farm Market & Bakery in Gibsonia, and host pick-your-own pumpkin activities in October.

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WINTER/SUMMER COVER CROP OPTIONS INFLUENCES VEGETABLE PRODUCTIVITY IN IRRIGATED SYSTEMS

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Prior cropping history, cover crop type, and supplemental nutrients are commonly needed to improve nutrient availability in organic production systems. Vegetable crops differ in their nutrient needs so alternative strategies for nutrient cycling with cover crops (CCs) are required. We utilized a variety of different winter (kale, winter wheat, or hairy vetch) and summer (buckwheat, proso millet, or black bean) CCs to assess their roles in nutrient cycling, weed management, and vegetable crop performance over a six year period. Vegetable crops evaluated included transplanted broccoli, snap beans and sweet corn grown in rotation. Additional nitrogen additions (feather meal) for broccoli and sweet corn supplemented the CC cycling and attempted to meet the vegetable crops N requirements. This presentation provides some detailed suggestions on how to use and evaluate nutrient management strategies for enhance crop performance in irrigated organic cropping systems where initial organic matter levels are low and soils are nutrient poor.

Winter CCs were established in September of each year after vegetable crop residues were soil incorporated. Cover crop fresh weight was measured prior to transplanting broccoli and again prior to direct seeding snap beans and sweet corn. After winter CCs were soil incorporated, summer CCs were planted. The winter CC and summer CC were planted such that there were nine (9) different combinations used to assess CC performance and influences on vegetables (Table 1). In addition to the cover crops, organic N fertilizer (feather meal; 13% N) was broadcast and incorporated 30 days after transplanting broccoli or seeding sweet corn, at 50 and 100 lbs. N/A, respectively. During six seasons (2016-2021; 2 vegetable rotation cycles), we evaluated cover crop productivity, weed pressure, and vegetable (broccoli, green bean, sweet corn) crop performance (plant growth and yield).

Table 1. Average productivity of broccoli, green beans and sweet corn in different winter (WCC) and summer (SCC) cover crop combinations (2016-2021).

	Broccoli Head Wgt (lbs./A)			Bean Pod Wgt (lbs./A)			Sweet Corn Ears (doz./A)		
	Black Bean	Proso Millet	Buck-wheat	Black Bean	Proso Millet	Buck-wheat	Black Bean	Proso Millet	Buck-wheat
Kale	4016	3592	5012	2787	4243	3317	879	1108	1189
Wheat	4508	4701	5846	2832	4199	3734	855	1142	1141
Vetch	6783	6856	8062	1461	3414	2966	1016	1242	1317

Sign. (0.05) WCC** SCC^{ns} WCC^{ns} SCC^{ns} WCC** SCC^{ns}

Kale CC's consistently produced the least amount of biomass (< 4,000 lbs./A) even though plant establishment was considered good to excellent. Winter wheat CC varied from 6-9,000 lbs. fresh biomass/acre, while vetch generally produced the most biomass (6-13,000 lbs. fresh biomass/acre). Biomass differences depended on when it was mowed and incorporated. In plots growing broccoli or sweet corn, feathermeal (13% N) was added to improve soil nitrogen nutrition. Broccoli yield was significantly improved when grown in vetch CC vetch compared to wheat or

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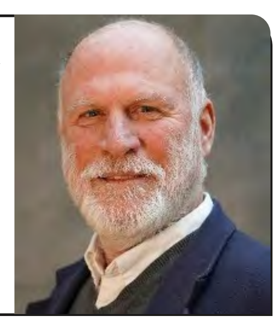

kale (Table 1). Broccoli yield differences with WCCs were attributed to improvements in head size (weight/diameter), head quality (more marketable heads), and % marketable plants. Winter CC's had no significant effect on bean pod weight during the study as plants were heavily inoculated with rhizobia. Sweet corn yield (doz. ears/A) were also significantly better when grown in vetch CC compared to wheat or kale (Table 1). Summer CCs had less impact on broccoli, bean or corn productivity (Table 1).

Weed growth in June also changed relative to the type of CC grown (Table 2). Weed biomass in kale CC was significantly lower than in wheat or vetch CCs. Summer CCs of millet and buckwheat established quickly and both produced significantly more biomass than black bean which was important in summer weed management (Table 2). In addition, buckwheat consistently suppressed weed better than millet or black bean. Desert soils are known to be low in organic matter and at the start of the study, the soil had 1.36% OM. After six years of CC additions, soil organic matter levels changed by 22-38 percent (Table 2). Both vetch and buckwheat CCs significantly increase soil OM levels compared to other CCs.

Table 2. Weed pressure (% of total biomass) and percent (%) change in soil OM (2016-2021).

	Weed Pressure (% total)				Organic Matter (% ↑)		
	Black Bean	Proso Millet	Buck-wheat		Black Bean	Proso Millet	Buck-wheat
Kale	31	35	25		22.2	24.2	27.9
Wheat	71	58	43		24.4	25.1	29.3
Vetch	68	55	45		34.9	34.4	38.8
Sign. (0.05)	WCC** SCC*				WCC*** SCC*		

Conclusions: Both WCCs and SCCs and the addition of supplemental organic fertilizer is important when trying to improve vegetable productivity, manage weeds, and improve soil organic matter and nitrogen availability. Summer CCs are not commonly used in many organic systems as they take farm space that reduces options for vegetables. However, used in combination with winter CCs, production approaches can be developed that enhance soil fertility and quality, optimize vegetable crop productivity, minimize weed pressure, and that have long-term sustainability for growers.

IMPROVING SOIL HEALTH AND CROP PERFORMANCE IN VEGETABLE ROTATIONS WITH A FOCUS ON COVER CROPS

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Vegetable growers should take time each year to revisit their rotations and make plans for the next growing season including using cover crops for soil heath benefits and other services.

Services that cover crops provide:

1. **Returning organic matter to the soil to maintain soil health.** Vegetable rotations are tillage intensive and organic matter is oxidized at a high rate. Cover crops help to maintain organic matter levels in the soil, a critical component of soil health and productivity. Brassicas and winter legumes provide the most biomass followed by ryegrasses and then rye.
2. **Providing winter cover.** By having a crop (including roots) growing on a field in the winter you recycle plant nutrients (especially nitrogen), reduce leaching losses of nitrogen, reduce erosion by wind and water, and reduce surface compaction and the effects of heavy rainfall on bare soils. Cover crops also compete with winter annual weeds and can help reduce weed pressure in the spring.
3. **Providing fall and early winter cover and then winter killing**. The use of winter killed cover crops are very useful when early spring (March or April) plantings of vegetable crops such as potatoes, peas, cole crops, early sweet corn, or early snap bean crops are being planned. By winter killing, cover crop residue is more manageable and spring tillage and planting can proceed more quickly.
4. **Reducing certain diseases and other pests.** Cover crops help to maintain soil organic matter. Residue from cover crops can help increase the diversity of soil organisms and reduce soil-borne disease pressure. Some cover crops may also help to suppress certain soil borne pests, such as nematodes, by releasing compounds that affect these pests upon decomposition. One system would be planting mustards in August or early September, tilling them into the soil to provide some biofumigation in October, and then planting a small grain crop for winter cover. Spring planted mustards can also work ahead of later spring planted vegetables.
5. **Providing nitrogen for the following crop**. Leguminous cover crops, such as hairy vetch or crimson clover, can provide significant amounts of nitrogen, especially for late spring planted vegetables. Hairy vetch is particularly well suited for no-till systems and can provide full nitrogen requirements for crops such as pumpkins and partial requirements for crops such as sweet corn, tomatoes, or peppers.
6. **Improving soil physical properties.** Cover crops help to maintain or improve soil physical properties and reduce compaction. Roots of cover crops and incorporated cover crop residue will help improve drainage, water holding capacity, aeration, and tilth. The use of large tap rooted cover crops such as forage radish or oilseed radish are particularly well adapted to these uses.

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7. **Setting up windbreaks in the fall for spring planted vegetables.** Small grain crops will overwinter and grow tall enough in to provide wind protection for spring planted vegetables. Rye has been the preferred windbreak because tall types are still available, and it elongates early in the spring. While barley is also early, tall varieties are not generally available. Wheat and triticale are intermediate and later.

8. **Developing no-till, bio-strip-till, and bio-bed preparation systems.** There is much opportunity to increase the use of no-till and bio-tillage systems. The key will be selecting the right cover crop for the desired system. Rye, crimson clover, subclover, tillage radish, spring oats, and other cover crops have been used successfully for no-till vegetables. One innovative system that uses a combination of winter killed covers and standard covers is bio-strip-till. In this system, a high biomass cover crop such as rye or vetch is planted with strips of forage or oilseed radish in rows where spring planting will occur. Another system uses rye strips with forage radish planted where the beds will be next year.

Cover crop planting windows vary with crop and timely planting is essential to achieve the desired results. There are many cover crop options for late summer or fall planting including:

Small Grains
Rye is often used as a winter cover as it is very cold hardy and deep rooted. It has the added advantage of being tall and strips can be left the following spring to provide windbreaks in crops such as watermelons. Rye makes very good surface mulch for roll-kill or plant through no-till systems for crops such as pumpkins. It also can be planted later (up to early November) and still provide adequate winter cover. Wheat, barley, and triticale are also planted as winter cover crops by vegetable producers.

Spring oats may also be used as a cover crop and can produce significant growth if planted in late August or early September. It has the advantage of winter killing in most years, thus making it easier to manage for early spring crops such as peas or cabbage. All the small grain cover crops will make more cover with some nitrogen application or the use of manure.

To get full advantage of small grain cover crops, use full seeding rates and plant early enough to get some fall tillering. Drilling is preferred to broadcast or aerial seeding.

Ryegrasses
Both perennial and annual ryegrasses also make good winter cover crops. They are quick growing in the fall and can be planted from late August through October. If allowed to grow in the spring, ryegrasses can add significant organic matter to the soil when turned under, but avoid letting them go to seed.

Winter Annual Legumes
Hairy vetch, crimson clover, field peas, subterranean clover, and other clovers are excellent cover crops and can provide significant nitrogen for vegetable crops that follow. Hairy vetch works very well in no-till vegetable systems where it is allowed to go up to flowering and then is killed by herbicides or with a roller-crimper. It is a common system for planting pumpkins in the region but also works well for late plantings of other vine crops, tomatoes and peppers. Hairy vetch, crimson clover and subterranean clover can provide from 80 to well over 100 pounds of nitrogen equivalent. Remember to inoculate the seeds of these crops with the proper Rhizobial inoculants for that particular legume. All of these legume species should be planted as early as possible – from the last week in August through the end of September to get adequate fall growth. These crops need to be established at least 4 weeks before a killing frost.

Brassica Species
There has been an increase in interest in the use of certain Brassica species as cover crops for vegetable rotations.

Rapeseed has been used as a winter cover and has shown some promise in reducing the levels of certain nematode in the soil. To take advantage of the biofumigation properties of rapeseed you plant the crop in late summer, allow the plant to develop until early next spring and then till it under before it goes to seed. It is the leaves that break down to release the fumigant-like chemical. Mow rapeseed using a flail mower and plow down the residue immediately. Never mow down more area than can be plowed under within two hours. Note: Mowing injures the plants and initiates a process releasing nematicidal chemicals into the soil. Failure to incorporate mowed plant material into the soil quickly, allows much of these available toxicants to escape by volatilization.

Turnips and mustards can be used for fall cover but not all varieties and species will winter over into the spring. Several mustard species have biofumigation potential and a succession rotation of an August planting of biofumigant mustards that are tilled under in October followed by small grain can significantly reduce diseases for spring planted vegetables that follow.

More recent research in the region has been with forage radish. It produces a giant tap root that acts like a bio-drill, opening up channels in the soil and reducing compaction. When planted in late summer, it will produce a large amount of growth and will smother any winter annual weeds. It will then winter kill leaving a very mellow, weed-free seedbed. It is an ideal cover crop for systems with early spring planted vegetables such as peas. Oilseed radish is similar to forage radish but has a less significant root. It also winter kills. Brassicas must be planted early to mid-August through mid-September for best effect.

Mixtures to Provide the Best Range of Services

It is important to choose cover crops that provide the maximum service benefits. Research in the regions has shown that generally mixtures of 3 cover crops providing different services maximizes benefits and creates conditions that favor soil microbial diversity.

Mixtures of rye with winter legume cover crops (such as hairy vetch) have been successful and offer the advantage, in no-till systems, of having a more rapidly decomposing material with the longer residual rye as a mulch. Other winter legume-small grain, winter legume-Brassics, small grain-Brassica, and small grain-winter legume-Brassica combinations have been successful.

Spring Planted Cover Crops

Where fall cover crops were not planted due to late harvest, spring cover crops can be planted in early April to provide soil health benefits where vegetables and field crops are not scheduled until late May or the month of June.

The most common cover crop options for late March or early April planting include spring oats, mustards and annual ryegrass. Plant oats at 90-120 lbs per acre, mustards at 10-20 lbs per acre, and annual ryegrass at 20-30 lbs per acre.

Field peas are another option; however, we are somewhat south of the best zone for spring planting. One type of field pea is the winter pea which is often fall planted in our area but can be spring planted. It has smaller seed so the seeding rate is 30-60 lbs per acre. Canadian or spring field peas are larger seeded and used as a spring cover crop planted alone at 120-140 lb/A.

Mixtures can also be used. Field peas are well adapted to mixing with spring oats or with annual ryegrass. Reduce seeding rates of each component when using in mixtures. Recommended seeding rates are 70 lbs of oats per acre and 40 lbs/A of Austrian winter peas or 80 lbs/A of Canadian or spring field peas.

Many mustard family crops have biofumigation potential. When allowed to grow to early flower stage and then incorporated into the soil, they release compounds that act as natural fumigants, reducing soil borne disease organisms. Some biofumigant mustard varieties and blends include 'Pacific Gold', 'Idagold', 'Caliente', 'Trifecta', and 'Kodiak'. Other mustard family crops serve as non-hosts, trap crops, or deterrents for pests. In research at the University of Delaware biofumigation using early spring planted biofumigant crops such as 'Image' radish, 'Dwarf Essex' rapeseed, or 'Nemat' arugula showed potential for managing root knot nematode populations. When used as a biofumigant, mustard family cover crops should be grown to achieve maximum biomass by adding 60-100 lbs of nitrogen per acre. Nitrogen is also required to produce high biomass with spring oats and annual ryegrass at similar rates. When planting mixtures with peas, nitrogen rates should be reduced.

An often-forgotten spring seeded legume crop that can also be used is red clover. Red clover can be frost seeded into small grains, seeded alone, or mixed with spring oats or annual ryegrass. Seeding rates for pure stands would be 10-16 lbs/A, for mixtures 6-10 lbs/A.

Summer Cover Crops

Where possible, vegetable growers should consider the use of summer soil building crops. This can be between spring and fall crops, prior to mid-season plantings or anytime there is about 6-8 weeks of fallow time. Use of these summer soil improving crops can help maintain or increase organic matter levels, address certain soil disease issues (fungal pathogens, nematodes), add nitrogen to the soil (in the case of legumes), reduce weed pressure, and improve soil physical characteristics.

The following are some soil building crops for summer use that I recommend:

Legumes

Cowpea (Vigna unguiculata)
Also known as blackeye or southern pea, this crop is underutilized in our area. It is fast growing with peak biomass often in 60 days. Cowpeas can fix up to 100 lbs of N per acre with biomass of 3000-4000 lbs/a. Cowpeas grow well in poor soils and can handle droughty conditions. Drill at 40-50 lbs per acre. Certain varieties such as California Blackeye #5 and Mississippi Silver are poor nematode hosts and will be beneficial in systems where root knot nematode is a problem. See this site for nematode ratings of different cowpea varieties http://edis.ifas.ufl.edu/in516#TABLE_1. Cowpeas also can be harvested in the immature pod stage as a fresh legume so can serve dual purpose in small farms.

Soybean
Soybean can also be a good cover crop drilled at 60 lbs per acre. Forage-type soybeans produce considerable biomass and make excellent cover crops. For nematode suppression, use of root knot nematode resistant varieties may be beneficial. Edamame types can be harvested and sold in green pod stage and the residue returned to the soil for soil building, again serving a dual purpose on small farms.

Sunnhemp (*Crotalaria juncea*)
Sunnhemp is a tropical legume that is used extensively for soil building in countries such as Brazil and India. Drill 20-30 lbs of seed per acre. Sunhemp can produce very high amounts of biomass (10 ton biomass is not unheard of in Florida – amounts will be lower here on Delmarva, expect 3-4 tons). It is a high nitrogen fixing legume and can contribute over 100 lbs of N to a following crop. Sunhemp grows very fast in the summer, reaching 6 feet or taller in 8 weeks. However, a better way to manage sunnhemp is to let it grow to about 1-3 feet tall, then mow it and let it regrow again. If allowed to get too tall and old the stems will become tough and fibrous and will not decompose rapidly. Sunnhemp is a day length sensitive crop. It will grow any time during the summer; however, it will not flower and go to seed until the days start getting shorter in very late summer.

Non-Legumes

S**udangrass and Sorghum-Sudangrass hybrids (Sorghum bicolor x S. sudanense)**
Sudangrass is a forage crop in the Sorghum family. Sorghum-sudangrass is a cross between forage or grain sorghum and sudangrass. These are warm-season annual grasses that grow well in hot conditions and produces a large amount of biomass. Plant at 20-40 lbs per acre drilled. Of all the non-legumes, it is the most useful for soil building. Sorghum-sudangrass will often reach 6 ft in height. Like sunnhemp, it can be mowed and allowed to regrow to enhance biomass production and have younger material that decomposes more quickly. Expect 3-4 tons of biomass addition per acre. As a grass, to get the most growth you will need to add nitrogen fertilizer (40-80 lbs/a). If incorporated at a young stage, the nitrogen will be re-released for the following crop. Sorghum-sudangrass is very effective at suppressing weeds and has been shown to have allelopathic and biofumigant properties. Research on nematode suppression by sorghum-sudangrass is mixed with some studies showing that sorgum-sudangrass suppresses nematode levels. Choose finer stemmed, leafy varieties when available. Brown midrib types will decompose more quickly because they have less lignin.

Forage-type Pearl Millet (*Pennisetum glaucum*)

Pearl millet is a tall summer annual grass that grows 4 to 8 ft. tall. It is well adapted to sandy and/or infertile soils and does well in the summer heat. Forage types are better adapted for soil improvement than the grain types. Seed at 20-30 lbs/a drilled. Expect 3-4 tons of biomass addition per acre. Again, as a grass, to get the most growth you will need to add nitrogen fertilizer (40-80 lbs/a). Pearl millet has been shown to suppress some nematodes. Forage pearl millet can make a good mulch for late-summer planted crops no-till or strip till.

All these crops above can be planted from late May through late July for soil improvement use.

ASSISTANCE AVAILABLE TO PRODUCERS TO PROMOTE SOIL HEALTH AND GUIDANCE FOR NAVIGATING CONSERVATION PROGRAMS

Scott Heckman, USDA- NRCS

The Natural Resources Conservation Service (NRCS) can provide financial and technical assistance to agricultural producers and non-industrial forest managers through various conservation programs in order to address natural resource concerns and deliver environmental benefits. Such benefits would include improved water and air quality, increased soil health, reduced soil erosion and sedimentation, improved or created wildlife habitat, and mitigation against drought and increasing weather volatility.

With these voluntary conservation programs, understanding which one is best suited for the producer can be a challenge. Together with the producer, NRCS can provide guidance to navigate through these programs in order to assist the producers to invest in solutions that conserve natural resources for the future while also improving ones operation.

BASIL YIELD, QUALITY AND RESOURCE USE EFFICIENCY USING ALTERNATIVE SOILLESS SYSTEMS

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Soilless or hydroponic vegetable production is becoming more popular due to the benefits of increased yield, increased quality, reduced potential for pollution into the environment and the highly efficient use of water and nutrients. With the increasing unpredictability of weather events due to climate change, and subsequent changing pest pressures, indoor agriculture and soilless production offers a pathway to sustainable vegetable production. Accordingly, soilless production adoption is expected to continue to increase across the world. Soilless or hydroponic production systems refer to any plant production system that does not require soil. There are different soilless production systems that we can classify in two main categories: i) growing media-based systems including variations with alternative growing media (organic or synthetic), containers (pots, slabs, etc.) and solution delivery method (drip, subirrigation) and ii) water culture or hydroponic systems in which plants are grown directly in a nutrient solution without need of a growing medium. These systems could be further classified in a) static growing systems in which the nutrient solution is static and is held in a container, like in the case of the floating or deep-water culture (DWC) system or the Krakty system; and b) non-static growing systems, in which the nutrient solution is circulating and is delivered to the plants in different ways like in the nutrient film technique (NFT), or the aeroponic systems. The variation in hydroponic growing techniques invites the question, "how does the type of soilless system affect crop growth and quality?" The effects of the different types of soilless growing systems on crop yield, quality, and resource use efficiency, have not been well researched. Popular soilless crops in the Mid-Atlantic region are tomatoes, cucurbits, strawberries, lettuce and leafy vegetables, and fresh herbs. In a study conducted at Penn State, we sought to better understand how different soilless growing methods affect characteristics of production such as yield, quality, and resource use efficiency. Over the last two years a study was conducted in a high tunnel at the Penn State Russell E. Larson Agricultural Research Center to assess and compare the effect of four different soilless production systems (NFT, DWC, subirrigation, and Kratky), and a soil-based raised-bed production system, on yield, nutritional value, and resource use efficiency of 'Italian Genovese' and 'Dark Opal' basil. Treatments were arranged according to a split-plot experimental design with three replications. Each production system was planted on the same day, grown under the same environmental conditions, and fertilized with the same nutrient solution. It is important to recognize that optimal management of the growing systems tested may require adjustments that are specific to each system. However, this study took a universal management approach that may have unintentionally favored the performance of certain systems over others, which is part of what makes comparisons between alternative growing systems challenging. Considering these premises, consistent large variations were found between the different systems for all the parameters of interest. The highest yielding system was the floating or DWC system, recording 21% higher yields than the second highest yielding system, NFT. The most efficient energy, water and nutrient use system was the Kratky (also known as "air-gap") system recording 42% less water use than the second most water efficient systems, NFT, Subirrigation and DWC. The highest nutritional quality systems, measured in terms of total phenolic compounds and total antioxidant activity, were observed in basil grown in soil and subirrigation. This study highlights how different growing systems can provide different benefits to the grower, depending on what the grower wants to prioritize in terms of yield, quality, and resource use efficiency.

MANAGING IPM WITH CONTROLLED ENVIRONMENT AGRICULTURE STRAWBERRIES: COMMON PEST, DISEASE, AND ABIOTIC DISORDERS

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Summary
Controlled environment agriculture (CEA) is a method of growing crops in protected environments that potentially reduces water, fertilizer, and pesticide inputs. At the same time, CEA products can be grown closer to the consumer year-round regardless of external climate pressures. Despite these benefits, pest, disease, and abiotic disorder challenges remain unavoidable. Based on four strawberry crop cycles in climate-controlled greenhouses at Cornell University and lessons learned from commercial CEA strawberry operations in the United States, we will discuss five common disorders that continue to challenge CEA strawberry operations. We will also discuss implementing DMAIC (duh-may-ik), a Lean Six Sigma technique, a framework that can lead to early detection and effective management of these problems. Six Sigma is data-driven and methodological process that strives to improve various business processes towards zero defects, errors, or mistakes.

Western Flower Thrips *(F. occidentalis)*
Western flower thrips are slender insects about 1mm long that can cause distorted/discolored flower petals and dull fruit. Thrips are one of the most devastating pests that affect strawberry growers because they quickly reproduce especially when pollen is available. Thrips are incredibly difficult to control once they appear because they are increasingly becoming resistant to conventional chemical control treatments. Therefore, reacting to a thrips outbreak once it already occurs is possibly the worst strategy to implement. Proactively preventing a thrips outbreak from occurring in the first place is, in most instances, the best strategy to implement. Thrips prevention entails proactively releasing beneficial insects such as *Neioseiulus cucumeris, Amblydromalus limonicus*, bug *Orius laevigatus,* or others recommended by biologicals supply companies ahead of time. Establishing a healthy population well before strawberry flowering occurs is critical. Furthermore, proper implementation of these beneficials is important because, like all living organisms, beneficial insects have optimal environmental thresholds to survive. Beneficials must be properly dispersed in specific densities and locations depending on their concentration and product packaging (i.e. bran or sachets).

Two-Spotted Spider Mites (*Tetranychus urticae*)
Two-spotted spider mites are tiny 8-legged pests which can cause mottling and webbing of leaves and distorted growing points. Spider mites are another devastating pest that inhibits strawberry production. These spider mites are typically found on the undersides of leaves and typically requiring a magnifying hand lens to see. They are especially prevalent in environments with low relative humidity, warm temperatures and under high nitrogen fertilizing conditions. Heavy infestations of these spider mites can result in reduced strawberry yields because the mites feed by destroying leaf chlorophyll which unfortunately leads to bronze foliage. Strategies to proactively detect spider mite infestations entail careful routine pest counts with a hand lens. Paying particularly close attention to undersides of leaves and observing webbing or downward curling older leaves can be helpful when looking for spider mites. Weekly scouting using standardized scouting patterns can also be useful. Some beneficial predator mites that can proactively prevent or reduce spider mite populations include *Phytoseiulus persimilis, Mesoseiulus longipes*, and *Neoseiulus californicus.*

Christopher Levine is currently pursuing a Master of Science in Horticultural Biology focused on Controlled Environment Agriculture. He received his Bachelor of Science from Cornell University in 2020, where he conducted independent research in the CEA Lab while competing on the men's varsity tennis team. Levine has experience in CEA ranging from plant mineral nutrition to lighting and environmental control. Prior to his M.S., Levine conducted research studying the effects of low potassium hydroponic nutrients on baby leaf spinach. Levine has also gained industry experience from Aerofarms, a commercial leader in indoor farming, where he worked as a consultant in their R&D group. Currently, Levine is researching methods to optimize airflow uniformity and control on indoor strawberry production. Levine's ultimate goal is to advance the indoor farming industry by providing more efficient solutions that allow farmers to grow crops using fewer resource inputs.

Powdery Mildew (*Podosphaera aphanis var. aphanis*)

Strawberry powdery mildew is characterized by curling of leaves following by gray/white powdery fungal growth on the underside of leaves which can begin as small colonies and spread to cover entire leaves. Powdery mildew can also infect fruit and young fruit, rendering it unmarketable. Leaves are most susceptible to infection. W is a common foliar disease that negatively impacts strawberry production as well. However, when properly identified and addressed, it can be resolved effectively. Powdery mildew frequently occurs under high humidity and temperatures between 60-80°F. Preventative fungicides for edible crops include: Bacillus subtilis (ex: Cease), Potassium bicarbonate (ex: Milstop), Streptomyces (ex: Actinovate SP), hydrogen dioxide (Oxidate 2.0). Repeat application is typically necessary.

Gray Mold (*Botrytis cinerea*)

Gray mold is another prevalent pathogen that inhibits the production of marketable strawberries. Gray mold can first appear on green fruit as a firm brown lesion which expands from the cap end. However, gray mold is often most clearly noticeable on ripe fruit just prior to or after harvest. The brown regions may look fuzzy due to sporulation under humid conditions. Main causes that lead to gray mold include periods of cool and wet environmental conditions as well as leaving dying leaves or fruit on plants which serve as common infection points. When these conditions are combined with wind and water movement, it can result in ideal fungal spore germination and spread across a farm. Management strategies that best control gray mold include cultural and sanitation techniques. This entails removing dying plant material, overly ripe fruit, ensuring proper airflow over and under the plant canopies. Furthermore, tool sanitation and proper worker hygiene can help reduce the spread of gray mold. Overhead irrigation should be avoided as well. Periodic application of the preventative fungicides suitable for edible crops noted above can help prevent or reduce the severity of gray mold.

Leaf/Calyx Tipburn

Tipburn is a common abiotic disorder that occurs in strawberry plants. Tipburn is easily witnessed by observing browning of leaf and flower calyx edges. Although growers may attribute this issue to a calcium deficiency from inadequate fertilizers, the more common result of tipburn stems from poor environmental conditions leading to insufficient supply to leaves/calyx when they were young/developing tissues. Low nighttime relative humidity (high vapor pressure deficit) exacerbates leaf/calyx tipburn. Calcium tipburn may be even more prevalent during the winter when outside air comes into the greenhouse with routine ventilation cycles. The cold outside air is often very dry due to low moisture holding capacity causing low night-time humidity. Reducing the severity or mitigating this issue can be achieved by implementing a high-pressure mist system that is able to increase relative humidity to acceptable levels around 60%.

Implementing DMAIC (Define, Measure, Analyze, Improve, Control)

DMAIC informally pronounced "duh-may-ik" is a framework for problem solving that represents the five phases of Lean Six Sigma approach often used in manufacturing. DMAIC which is based on the scientific method stands for define, measure, analyze, improve, and control. Thrips pests will be used as an example below with defining the problem being the first step.

1. During the define phase, the project team must document what the exact problem is, the business reasons for addressing the problem, a target goal, a timeline, what is considered within and out of the project scope, and team members assigned to the task.

    Thrips example: Grower identifying thrips as a concern and why an infestation could result in economic losses for the farm. Team members assigned to the task could include the individuals responsible for carrying out scouting of pest populations, growers, or consultants that help oversee the process, and workers that apply predator mites.

2. Measuring and quantifying the problem is the second step. This may entail detailed bi-weekly pest population records and a standard operating procedure the outlines this task.

    Thrips example: an organized spreadsheet and standard operating procedure that records bi-weekly pest counts from sticky cards or flowers. Steps must be taken on training and educating the workers on what to look for. Detailed and clear steps on carrying out the work should also be made.

3. Analyzing the problem is the third step. This may entail learning where most of the pest originates from or how they move into or within the farm. The pest may be more highly concentrated near doors, vents, or highly tracked pathways. The pest may be more concentrated on certain strawberry cultivars as well.

    Thrips example: grower, scout, extension agent, or biologicals consultant This may involve an entomologist or another expert that can interpret the pest counts and succinctly report it in an easily understandable manner.

4. Improving is the fourth step. Data from the analysis must be used to make improvements. Depending on what is the root cause, the team must implement solutions to reduce the severity of the problem. For example, if pest counts are more concentrated near highly tracked pathways, then efforts must be taken to reduce workers from spreading the pest throughout the room.

    Thrips example: This could entail a detailed strategy on how to address the problem. This could include a combination of cultural, biological, physical, and chemical control techniques and a scheduled outline of the strategy.

5. Control is the last step. In this step the team must develop a monitoring plan to track the updated process and develop countermeasures if in case there is a dip in performance (i.e. pest tolerance thresholds).

    Thrips example: This could include specific thresholds on the concentration of thrips in areas within a farm or number on certain flowers that would result in elevated response actions.

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SMART LIGHTING STRATEGIES FOR CONTROLLED ENVIRONMENT AGRICULTURE

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Supplemental lighting is often needed for ornamental or vegetable greenhouse production to complement sunlight during the darker months of the year. Plant factories, or vertical farms, entirely depend on electric light fixtures. Lighting can assure the production of high-quality crops. However, electricity costs for lighting can be high, and can be up to 30% of the total operating costs. Poor supplemental lighting strategies can greatly reduce the profitable of controlled environment agriculture operations, whether they are greenhouses or vertical farms.

To assure they growers get the maximum value from their lighting systems, there are two important questions that need to be answered: 1) what types of light fixtures are most profitable and 2) what is the best way to operate those lights?

Lighting control strategies

There are essentially three ways to automate operation of supplemental lighting systems: timers, threshold control, and DLI control. Timer control is cheap and easy, but is not capable of providing consistent day-to-day lighting conditions. On sunny days, unnecessary supplement lighting may be provided, while not enough light may be provided on overcast days.

Threshold control is better and provides automatically supplemental light when there is little sunlight. Threshold control requires a light sensor, which preferably should be installed inside the greenhouse above the lighting system, so that the light readings reflect the amount of sunlight the crop receives. The lighting system can then automatically be turned on when the sunlight drops below a user-defined threshold.

DLI control aims to provide a specific amount of light by the end of the day. It requires a light sensor and a control system that can accumulate all the light readings over the course of a day. The controller can then determine when to provide supplemental light, with the goal of reaching a user-defined total amount of daily light (the daily light integral or DLI). A good DLI control system can provide more consistent day-to-day lighting conditions than timer- of threshold-based control.

HPS vs. LED fixtures: how to choose?

HPS vs. LEDs: Pros and cons. The choice between HPS and LED fixtures often is not a simple one. HPS fixtures are substantially less expensive than LED fixtures. But HPS fixtures are also less efficient and require more maintenance (bulb and fixture replacement) than quality LED fixtures. The question is largely one of capital versus operating expenses, although some LED fixtures can provide functionality that is not available in HPS fixtures: spectral control and precision dimming. Note that the higher efficacy of LED fixtures also means that they produce less heat. As a result, greenhouses with LED fixtures typically require more heating than those with HPS fixtures.

Capex. Capital expenses include both purchase and initial installation of the fixtures and are relatively easy to estimate, based on quotes from suppliers. Don't forget to also contact your electricity provider to see whether there are rebate programs for the purchase of more efficient LED fixtures. Note that there are dozens, if not hundreds of LED suppliers and not all of them have a strong track record. Important questions to ask when purchasing any supplemental lighting system include: what is the track record of the company, what warranty do they provide, how likely

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Dr. van Iersel's lighting research is supported by USDA-NIFA-SCRI Award 2018-51181-28365

is it that they will still be in business by the time the warranty expires, and what is the efficacy (light provided per unit energy) of the light fixtures. The latter should be measured by independent testing agencies. The Design Lighting Consortium has a great website that allows users to select light fixtures, based on specific criteria: https://www.designlights.org/our-work/horticultural-lighting/. Neil Mattson, professor at Cornell University, has developed an Excel spreadsheet that allows users to compare the cost of different lighting systems, including a rough estimate of electricity costs and payback time. The calculator can be accessed at https://www.hortlamp.org/outreach/determine-lighting/.

Opex. Accurate estimates of the electricity costs are much harder to get, since those depend on greenhouse location, configuration, local weather conditions, and the crop(s). To help growers get these estimates, we developed an on-line app. There are actually three versions of this app: the initial one assumes you have enough lighting capacity (the maximum amount of light your lighting system can supply) to reach your target daily light integral even on the darkest day of the year and calculates the electricity costs associated with providing just enough light to reach that DLI every day of the year. However, installing enough supplemental lighting capacity to reach the target DLI every single day is not economical. To read more about this calculator, see our Greenhouse Grower article at https://www.greenhousegrower.com/technology/a-new-way-to-determine-lighting-costs-at-your-greenhouse/.

We developed two additional calculators to simulate more realistic scenarios. The first one allows users to enter the specifications of their lighting system (lighting capacity, photoperiod, desired DLI). The app then determines both the electricity costs, as well as the number of days each year that growers can expect to reach their target DLI. The last app is similar, but takes the opposite approach. Users can specify how many days a year they want to be able to reach the target DLI and the app will determine the required lighting capacity (for a given photoperiod) and determine the associated electrical costs. All our calculators are freely available at https://www.hortlamp.org/outreach/determine-lighting/.

Lighting strategies that can reduce costs

Use supplemental light when there is little sunlight. The efficiency with which plants use light decrease and light levels increase. Because of this, supplemental light should be provided preferentially when sunlight levels are low. This is easily achieved with timers, since those are typically set to provide supplemental light early in the morning and/or in the evening. The concept of threshold control is also based on this concept, since supplemental is only provided when sunlight levels are relatively low. With DLI controllers, supplemental light typically also is provided mainly when sunlight levels are low. However, different controllers use different, and often proprietary algorithms, so ask your supplies for details.

Longer photoperiods. Also based on the concept that plants use light more efficiently when light levels are relatively low is the idea of providing the same DLI over longer photoperiods. Longer photoperiods reduce the instantaneous light level that is required to reach the required DLI. This has two advantages: the plants can use the light more efficiently, so with longer photoperiods you get more growth with the same amount of supplemental light and you do not need as many light fixtures to be able to reach the target DLI. But keep in mind that development of many crops, such as flowering, is affected by photoperiod. So for crops that have photoperiodic flowering responses, there are limits with regard to which photoperiods can be used. However, many leafy greens, for example, tolerate continuous light. Such crops are a great choice for providing longer photoperiods. Make sure to test how your specific crops respond to different photoperiods. For more information, please see the following articles: https://gpnmag.com/article/not-all-dlis-are-the-same/ and https://endowment.org/efficient-lighting-strategies-for-perennials/.

Better DLI control. As outlined above, there are different ways to control supplemental lighting fixtures: timers, threshold control, and DLI control. Only DLI control can provide truly consistent light conditions from day-to-day. As a result, a good DLI control system can result in more predictable production, something that is critical for greenhouses. Not all DLI control systems work the same, so ask your (potential) supplier for performance data of their specific system, preferable in a climate like yours. To learn more about our work on this topic, please see https://gpnmag.com/wp-content/uploads/2021/09/Precision-Control-of-Supplemental-Lighting_GPN_0921.pdf.

'Carry-over' DLI. A new development in lighting control is the concept of 'DLI carry-over'. This refers to lowering the target DLI following days that had a DLI that was above the target. Essentially, this approach uses the idea of averaging the DLI over multiple days. That can provide significant advantages over systems that control DLI on a day-by-day basis, using both supplemental lighting and shading. Less heading on sunny days can help reduce supplemental lighting needs on overcast days. Our simulations indicate that this can reduce electricity costs by $6,000 to $9,000 per acre per year. Read more about this concept here: https://www.greenhousegrower.com/technology/how-to-convert-sunny-days-to-energy-savings-in-the-greenhouse/.

Future improvements. Many CEA facilities have variable electricity costs, so it is obvious that, whenever possible, supplemental lighting should be provided when electricity costs are low. To better understand when and how much supplemental lighting should be provided, it is necessary to also have an idea of how much sunlight the crop is likely to receive on a specific day. Algorithms that account for variable electricity prices and use predictions of sunlight are currently being developed and will hopefully be available to the CEA industry soon. One topic that still deserves more attention is the demand charge. The demand charge is part of the electricity bill for all commercial facilities and this charge is based on the peak electricity use each month. The demand charge is often higher than the cost of the electricity itself. To lower the demand charge, supplemental light should be provided when the electricity use of the rest of the facility is relatively low. Such an approach to lighting control would require monitoring of the overall power consumption of a facility. To the best of my knowledge, not lighting control systems currently have this capability, but hopefully this will change.

LED LIGHTING FOR INDOOR PRODUCTION OF LEAFY GREENS

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Background

Indoor farms are burgeoning in the United States as growers and entrepreneurs find niche markets for year-round production of high-value specialty crops. Leafy greens, culinary herbs, and microgreens are among the most popular crops grown in vertical and container farms. The sole source of light for plant growth in most indoor farms is light-emitting diodes (LEDs), which allow for custom light quality, intensity, and duration to produce desired crop attributes, including yield, appearance, nutritional value, and flavor.

The intensity of photosynthetically active radiation (PAR, 400 to 700 nm) is crucial for plant growth and development. Plants not only convert PAR into chemical energy for photosynthesis, but also use light as a signal to adapt to the environment. Blue (400 to 500 nm), green (500 to 600 nm), and red (600 to 700 nm) light are in the wavelength range of PAR. Light outside this range, such as ultraviolet (UV, 280 to 400 nm) and far red (700 to 800 nm), can also influence plant growth. Most horticultural LED fixtures look purplish because they primarily emit red and blue light. Red and blue LEDs are effective at promoting photosynthesis and efficient in converting electrical energy into light. However, they make it difficult for growers to see insect pests and crop nutrient disorders. In contrast, LEDs that emit red, blue, and green light appear white and thus help with crop inspection. Our research explores how green and far-red light can benefit indoor production of leafy greens typically grown under red and blue LEDs **(Figure 1)**.

Green & Far-Red LED Lighting

There has been a misconception that green light is not useful for plants. Although chlorophylls absorb mainly red and blue light, leaves also absorb 70% to 80% green light. While the upper surface of a leaf absorbs most of the red and blue light, green light penetrates deeper into the leaf to drive photosynthesis. Moreover, green and far-red light reach deeper into a canopy than red and blue light and can elicit shade-avoidance responses, such as increased leaf expansion and upward leaf orientation. As a result, larger leaves capture more light energy to increase photosynthesis and thus, growth. Green and far-red light also contribute to photosynthesis directly.

Figure SEQ Figure * ARABIC 1. Different combinations of light colors used in our LED lighting

Although these phenomena indicate positive roles of green light in plant growth, effects of green light have been inconsistent in recent studies. In addition, if green and/or far-red light are to supplement red and blue light, how green light compares with far-red light is unclear. We performed an indoor experiment to determine how partly or completely substituting blue light with green and/or far-red light affected lettuce and kale growth.

Dr. Qingwu (William) Meng is an Assistant Professor of Controlled Environment Horticulture in the Department of Plant and Soil Sciences at the University of Delaware. He holds master's and doctoral degrees in Horticulture from Michigan State University. In the Delaware Indoor Ag Lab (DIAL), his research on environmental plant physiology aims to improve specialty crop production in greenhouses and indoor farms. He investigates environmental factors (e.g., light, carbon dioxide, and temperature) and root-zone factors (e.g., nutrient solution concentration and composition) relevant to crop yield and quality. Besides research, he teaches hydroponic food production and controlled-environment crop physiology and technology.

In our study, a partial or complete substitution of blue light with green or far-red light increased harvestable mass and leaf size of lettuce and kale (Figure 2). Increased yields can at least partly be attributed to increased leaf expansion and consequently, light capture for photosynthesis. However, substituting green light for blue light decreased foliage redness of red oakleaf lettuce ‘Rouxai’.

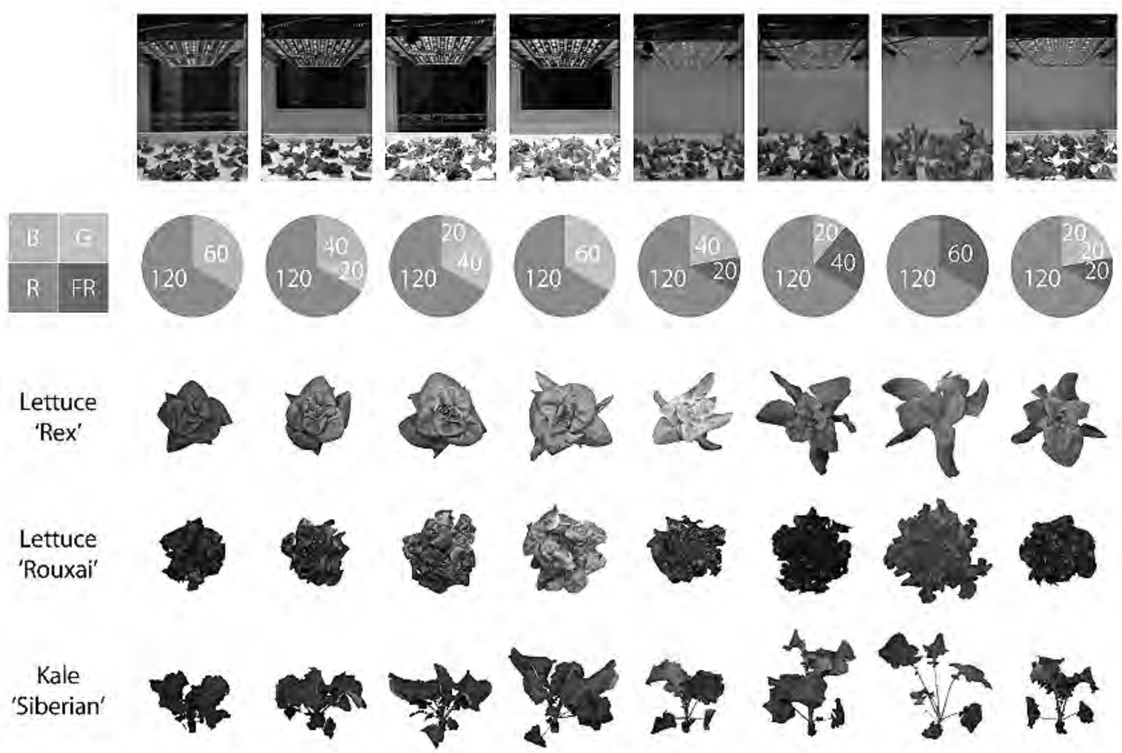

Figure 2. Lettuce and kale grown under eight lighting treatments from blue (B), green (G), red (R), and far-red (FR) light-emitting diodes. The number for each color of light indicates its intensity in μmol·m−2·s−1.

Green and Blue LED Lighting

Although the above study showed apparent benefits of green light in crop growth, it was unclear whether these responses resulted from increasing green light, decreasing blue light, or both. Therefore, we performed a follow-up indoor experiment on red-leaf lettuce to separate these two factors and better understand their roles in crop growth and quality attributes.

We found that blue light was the main driver of lettuce growth and quality attributes, with or without green light (Figure 3). At a fixed total light intensity, effects of green light on lettuce yield depended on blue light intensity. Substituting green light for red light did not affect shoot dry mass under low blue light (0 or 20 μmol·m−2·s−1) but decreased it under higher blue light (60 or 100 μmol·m−2·s−1). In addition, what may appear to be effects of green light on crop growth could instead be caused by changes to blue and/or red light. In practice, green light can be delivered, commonly through white LEDs, with low blue light and high red light to improve color quality for crop inspection without decreasing yields.

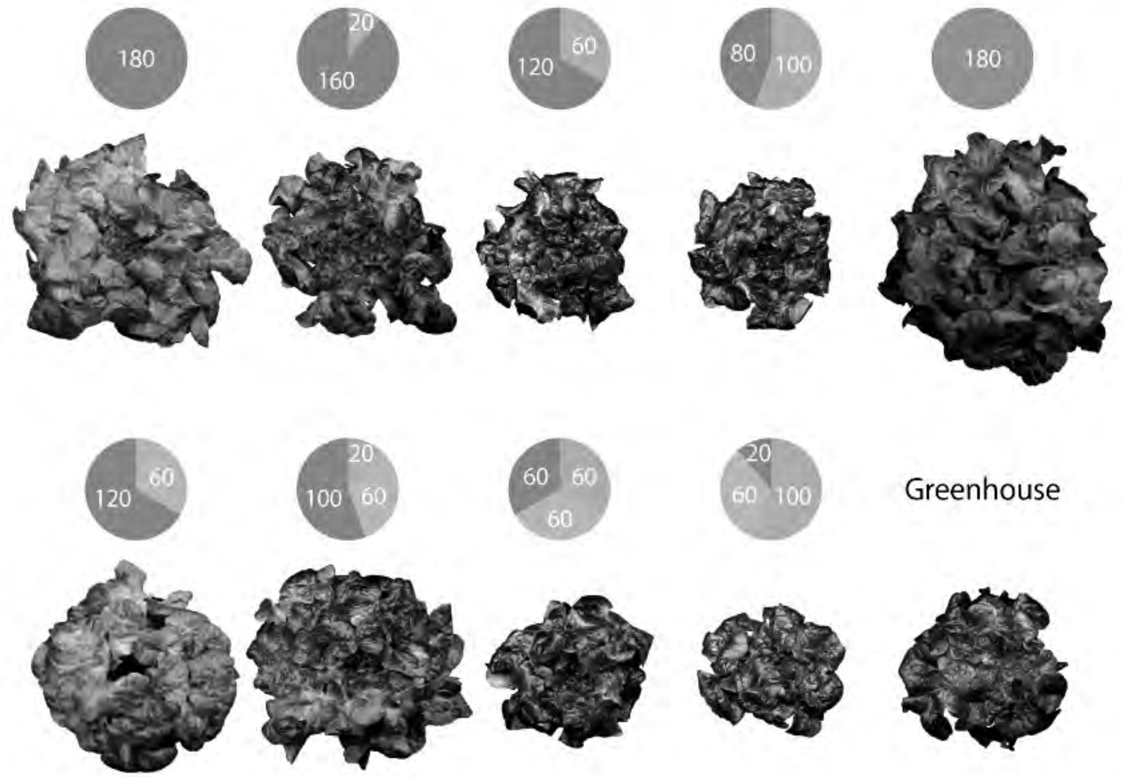

Figure 3. Mature red-leaf lettuce 'Rouxai' grown under the ten lighting treatments, which included eight combinations of blue and red light without or with green light, warm-white light (top right), or sunlight supplemented with high-pressure sodium lamps in a greenhouse. The number for each color of light indicates its intensity in µmol·m–2·s–1.

Acknowledgements
Research described here was performed in Dr. Erik Runkle's Controlled-Environment Lighting Laboratory (CELL) at Michigan State University. We thank Osram, Michigan State University's Project GREEEN, the USDA Specialty Crops Research Initiative, and horticulture companies that support vertical farming research at Michigan State University.

TOMATO SPOTTED WILT VIRUS AND RELATED TOSPOVIRUSES

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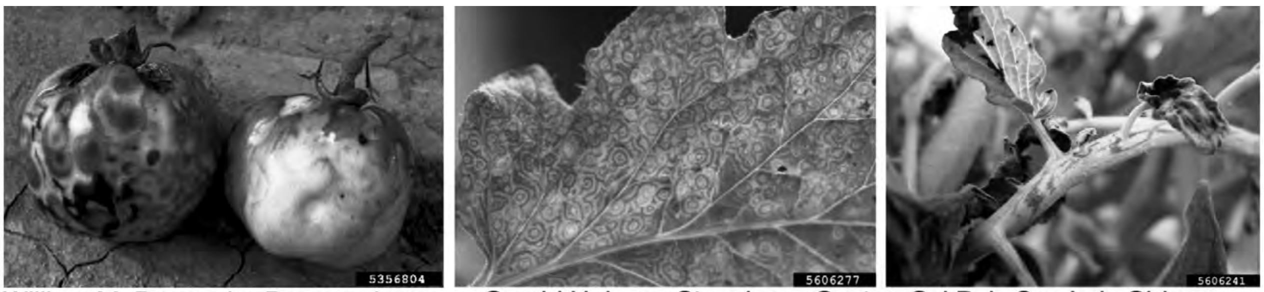
Tomato spotted wilt virus (TSWV)

TSWV infects over a thousand plant species and infection results in significant yield losses for many agronomically important crops. Typical virus symptoms include stunting, wilting, and necrotic or chlorotic concentric spots on susceptible plants. Many plants have an age-dependent susceptibility to TSWV. Physiological measurements of TSWV-infected plants revealed that photosynthesis, transpiration and water-use efficiency were significantly decreased in virus-affected plants.



William M. Brown Jr., Bugwood.org   Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

TSWV and related orthotospoviruses

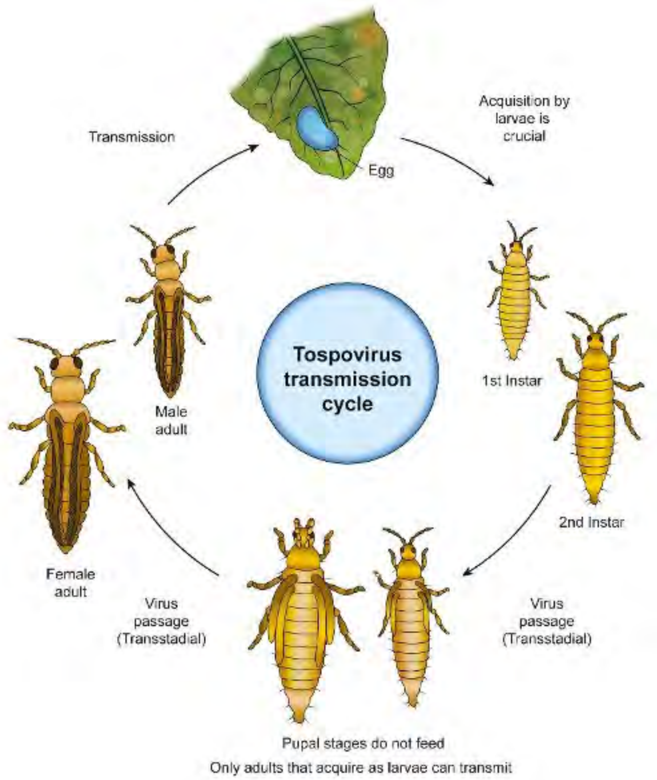
Frankliniella occidentalis, the western flower thrips, transmits at least seven orthotospoviruses including the tomato-infecting species: *Chrysanthemum* stem necrosis virus (CSNV), *Groundnut ringspot* virus (GRSV), I*mpatiens necrotic spot virus* (INSV), *Tomato chlorotic spot virus* (TCSV), and. TSWV is the type species of the genus *Orthotospovirus* in the family *Tospoviridae*, order *Bunyavirales*, and it is considered one of the ten most devastating plant viruses worldwide. In the past 20 years, the number of tospovirus species has grown to 26 viruses. Thrips-transmitted orthotospovirues are re-emerging and emerging threats to U.S. agriculture. In addition to the emergence of new tomato-infected viruses like TCSV, strains of TSWV that overcome the most effective and widely used resistance gene for tomato, Sw-5b, have emerged.

Biology of the thrips vector

Thrips are very small insects (generally <1 mm in length) that constitute the insect order Thysanoptera. It is estimated that there are more than 7,000 species of thrips. Thrips have a great diversity of feeding preferences and behaviors, but all thrips species that are vectors of tospoviruses are phytophagous insects. The most widespread and efficient vectors of tospoviruses are polyphagous, which increases the chances for virus acquisition and inoculation in diverse plant species. In addition to their role as vectors of tospoviruses, these thrips species are important pests due to the damage that results from their feeding. Large populations of thrips on young plants can stunt plants and delay crop

Anna Whitfield joined NC State in 2017 as a Chancellor's Faculty Excellence Program cluster hire in Emerging Plant Diseases and Global Food Security. Whitfield, a professor of entomology and plant pathology, is known internationally for her work on plant-virus-vector interactions. The long-term goal of her research is to develop biologically-based strategies for controlling viruses and arthropod vectors. Whitfield's research scholarship around virus-vector relationships is enabling development of innovative strategies that disrupt the cycle of disease in the field. At NC State, Whitfield works with emerging viruses and vectors that threaten food security. Whitfield studied entomology and plant pathology as a graduate student at the University of California-Davis, where she received her Master of Science degree, and at the University of Wisconsin, where she received her doctoral degree. Prior to joining NCSU, Whitfield was a professor of plant pathology at Kansas State University. Whitfield was raised on a small family farm in South Georgia, and it was there that her passion for agricultural research developed. These early experiences influenced her research that focuses on developing a safe, secure food supply that minimizes threats to grower and consumer health.

maturity and feeding by thrips on developing fruit causes blemishes and reduces marketability. Thrips are extremely small, highly mobile, and thigmotactic, and their egg and pupal stages are protected from pesticide exposure. These qualities also make them very successful invaders and vectors of viruses.



The tomato spotted wilt virus transmission cycle. Thrips eggs are oviposited into plant tissue and within a few days the first instar larvae emerge. Virus acquisition occurs during the larval stages after which the virus persists in the vector and is passed transstadially to the adult. The pupal insects may occur in the soil or leaf tissue and these stages are nonfeeding. Adults emerge and may disperse widely. Only adult thrips (male and female) that acquired the virus during their larval stages can transmit tospoviruses.

Transmission by thrips

In nature, tospoviruses are transmitted in a persistent propagative manner by thrips. Members of the TSWV and closely related tospoviruses are predominantly transmitted by western flower thrips (Frankliniella occidentalis). The primary driver of the worldwide emergence of tospoviruses has been the spread of western flower thrips. Overall, the western flower thrips is one of the most important vectors of tospoviruses worldwide due to its wide plant host range and expansive distribution across North and South America, Australia, Europe, and the Middle East.

TSWV has a unique insect developmental-stage dependent transmission cycle. Virus is acquired when larval thrips feed on TSWV-infected tissue. As thrips mature, they lose their ability to become efficient vector and pupal and larval thrips cannot effectively acquire virus and become virus transmitters. The pupal stages do not feed and thus do not acquire or inoculate virus. Both male and female adults are efficient virus transmitters and they can effectively disperse the virus over short and long distances. The small size of thrips makes them an efficient transport mechanism for viruses and thrips are often found in shipments of diverse types of plant materials.

Diagnosis

TSWV causes distinct foliar symptoms on some susceptible crops such as tomato groundnut (peanut), potato, and tobacco that are of diagnostic value. Confirmatory, laboratory-based assays include ELISA-based serological test using antibodies specific to the N protein. Rapid test kits for detecting virus in 15 min. or less are available from commercial vendors. The genome of several isolates of TSWV was sequenced and RT-PCR-based molecular detection methods are available.

Prevention

In case of perennials and vegetatively propagated plants and crops, virus can spread from infected mother plants through cuttings and tubers. Use of virus-free material is very effective in preventing disease outbreaks. TSWV is not seed-transmitted, and the primary source of infection in annual crops is mainly due to feeding by viruliferous thrips. Reducing yield losses due to TSWV infection is mainly through an integrated disease management (IDM) strategy that involves vector management by biological and chemical means, cultural practices, and growing TSWV resistant cultivars.

Plant resistance

Several natural resistance genes have been reported to control TSWV. The most widely used gene in tomato is Sw-5b. The Sw-5b gene is from Solanum peruvianum, a wild species of. Due to its durability and broad-spectrum resistance, the Sw-5b gene has been introgressed into many commercial tomato cultivars, becoming the main natural resistance source against TSWV for this crop. This broad-spectrum resistance is not just observed for TSWV isolates, but also for orthotospoviruses classified in other species phylogenetically-related to TSWV (for example tomato chlorotic spot virus (TCSV)). Newly developed tomatoes with transgenic resistance provide broad spectrum control for tospoviruses and are an attractive replacement for the failing Sw-5b gene.

Resistance-breaking TSWV (RB-TSWV)

The repeated use of a monogenic resistance source on a virus population selects virus mutants that are not sensed by the resistance gene product or that suppress the resistance mechanism. TSWV resistance-breaking (RB) isolates have been reported for Sw-5b in tomato. Two amino acids substitutions in NSm proteins, C118Y or T120N, overcome Sw-5b-mediated resistance by TSWV isolates. TSWV and other related viruses are capable of exchanging genome segments through a process called "reassortment." This evolutionary mechanism enables rapid change in virus populations and enables TSWV to adapt to new plant hosts, thrips vectors, and plant resistance genes. The durability of a resistance gene in the field can be prolonged with proper management of resistant cultivars.

HOW WE GROW TOMATO TRANSPLANTS

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- Start with the highest germination seed lot available.
- Hot water treat all Tomato seed.
    1. Loosely wrap seed in some type of mesh bag.(5M limit)
    2. Pre-warm seed for ten minutes at 100 degrees F.
    3. Place pre-warmed seed in the second bath at a temperature of 122 degrees F. for 25 minutes. (time and temperature are critical)
    4. Cool seed quickly in cold water for a minute or two.
    5. Spread seed out on a paper towel or newspaper in a warm low humidity area. It is critical that drying is immediate. Longer seed is damp the greater the loss of germination.
    6. Pack seed in a paper envelope if not sowing immediately.
- Germination- 75-80 degrees soil temperature. We use a 512 plug tray.
- After 50% emergence, move to a warm growing area to complete germination.(70-75 degrees F) The goal is to get the seed coat off of the seedling as soon as possible.
- Reduce temperature to 60-65 degrees F and begin fertilizing with a complete fertilizer at 100 ppm N once every 4-5 days. Plug fertilizer 13-3-13+ Ca & Mg. Low Phosphorus is important.
- Transplant into 50 count trays at first true leaf. (approximately 3 weeks from sowing)
- 60 degree F. nights 70 degree F. days. Adequate ventilation and air movement is important.
- Begin constant feed at 100ppm N. (17-4-17) Clear water about one time per week. Grow on the dry side.
- Four week finish time from a 512 plug transplant.
- Isolation of commercial varieties from garden varieties where possible.
- Five day schedule of preventative foliar sprays beginning at second true leaf stage. This practice is particularly important as the days get longer and watering becomes more frequent. Spays continue until the plants leave the greenhouse
- A few days before going to the field reduce the temperature to tone the plants.

Dave is a fourth generation farmer and the principal shareholder of Miller Plant Farm Inc. Located in York County, the greenhouse operation consists of about 63,000 square feet of heated growing area. They also farm about 160 acres, 50 of which are vegetables. Miller Plant Farm grows and supplies vegetable transplants directly to home gardeners at the Garden Center, to other retailers and many commercial vegetable growers in Pennsylvania and surrounding states. In 2011 Dave, along with his nephew Steve Slyder and son Dustyn Miller, built and opened a new retail Garden Center/Farm Market. Miller Plant Farm began a CSA in 2012 that in 2021 consisted of 700+ members. Dave has three grown children and five grandchildren.

WEED MANAGEMENT AND 20 YEARS OF NO-TILL SWEET CORN AT FRANKENFIELD FARM MARKET

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I've been growing and selling sweet corn for over 20 years. In 2002 we expanded operation from our seasonal farm wagon by the roadside to a permanent building at the farm. It was also in 2002 that we purchased a "new" used JD 7000 corn planter, converted it to no-till and started using it to no-till field corn, soybeans, sweet corn and pumpkins. The first few years I still did some tillage, especially for early sweet corn. I didn't like losing the soil health benefits of continuous no-till and cover crops just, so I could plant early sweet corn. As I built up my confidence and the soil structure improved, I began no-tilling all my sweet corn acreage.

I grow between 15 and 20 acres of sweet corn and about 2-3 acres of pumpkins, all no-till. The other vegetables I raise conventionally with raised beds, plastic, and drip tape. The primary market for all my produce is for our retail farm market. Excess corn and pumpkins are sometimes wholesaled to nearby farm markets.

No-till sweet corn is much more than not plowing to prepare the seedbed. Cover crops are a key component of the system. I only can irrigate certain fields, so about three out of four years a field will likely be in sweet corn. As soon as we finish picking a field it is mowed down. Then we burn it down with glyphosate plant a cover crop within about week or so, sometimes the same day. I believe this helps considerably with weed control. Any weed escapes are mowed and sprayed soon after harvest limiting weed seed production.

We purchased a no-till grain drill with a small seed box in about 2010 which gave us the ability to plant a variety of cover crops. Some years we have a need for straw, so I'll seed oats after my first few batches of sweet corn. The oats get cut in mid-September and bleached out and baled as straw and cereal rye gets seeded into those fields in early fall. For the past few seasons, I've also planted black oil sunflowers in late July and early August as a summer cover crop and then followed that with cereal rye in October. Prior using sunflowers as a summer cover crop, we seeded a mixture of forage sorghum, crimson clover, annual ryegrass, and radish. I taped off every other row in the main seed box and put the sorghum in there. Then in the small seed box I taped off the opposite rows and put in the mixture of crimson clover, annual ryegrass, and radish. That was then green chopped in late September and early October and fed to the cattle. The ryegrass and crimson clover overwintered and that was where i often planted my first sweet corn. I planted that mixture until mid-August when the forage sorghum seed was used up in the main box, I removed the tape and add cereal rye. I also remove the tape from the small seed box and continue planting the mixture of crimson clover, annual ryegrass, and radish until the end of September. In October I plant cereal rye by itself, sometimes with some annual ryegrass.

I normally aim to plant my first planting of sweet corn in early April. I have been planting into the fields where there was cereal rye, annual ryegrass, crimson clover, and radishes. The radishes winterkill leaving cereal rye, small annual ryegrass, and crimson clover. I don't do any herbicide treatment prior to planting, I plant into green living cover crop, and this also helps pull moisture from our slow to dry clay soils. Prior to corn emergence I will spray with glyphosate and a residual herbicide, currently Acuron. I select varieties that have good cold soil emergence; Temptation and Illusion have been a good early varieties.

Andrew Frankenfield is a Senior Extension Educator in Montgomery County on the Field Crops and Forages Team with Penn State Extension. In addition to working with field crop farmers he also works with vegetable producers in the area because of his vegetable knowledge since he also is a vegetable producer himself. He has his B.S. degree in Agribusiness and his M.B.A in Food and Agribusiness both from Delaware Valley College. He lives in Souderton on the family farm with his wife Tanya and three children Delaney, Tanner and Sage.

I typically plant at least one bicolor and one white variety with similar days to maturity and a full season variety. Usually, I wait a couple weeks or when they emerge and plant another planting toward the end of April. I use Growing Degree Days to calculate when a planting will be ready to harvest and when to plant the next planting. This method has worked well for me; it takes some time to keep track of the high and low temperatures each day but provides a consistent supply of corn during the growing season. My second planting will usually include another short-season variety and a full season variety. The 3rd thru 15th plantings is typically the same full season variety planted when the previous planting is spiking. I typically stop planting around July 15th which allows me to harvest into early October.

We also cut some of the cereal rye cover crop for straw just prior to flowering to bleach out for straw. If we have enough straw, we will burn down the rye cover crop at about knee high to keep it from getting too tall and becoming an issue to plant into. The beauty of no-till planting is I don't need to till the soil prior to planting. If it looks like it is going to rain later in the day and I was going to plant the next day anyway, I will go out and plant the field. Getting back into the field to spray it before the corn emerges is easier too after a rain when using no-till. I will also spray residual herbicides ahead of planting, especially in June or July when I am planting more frequently, typically every 4 or 5 days.

Planting into soil that has residue cover is good especially in dry periods because there is more moisture under the mulch. Very rarely will there not be enough soil moisture to germinate a planting. As you know uneven emergence or delayed emergence due to dry soil conditions will delay the maturity of your planting, causing headaches at harvest time. There is a balance however, too much residue, especially on my soil types will prevent the soil from drying enough to get into the field to plant. That's why I target burning down the cover crops at knee high, so there is good residue cover, but not too much like tall rye rolled down which will prevent the soil from drying at all. This residue also is beneficial for erosion control and slows evaporation losses. I also feel the cover crops open up the soil to allow the corn roots to get to moisture deeper in the soil profile during dry periods and allows me to delay irrigation for a few days until it rains again, or I decide it is time to irrigate. I irrigated using municipal water (fire hydrant) for 5 years until I drilled a well in 2017. I would rather not irrigate because I use traveling gun and it takes a time to set everything up and manage it but I realize once the crop begins to show signs of stress I need to.

Keys to success.
Avoid soil compaction-this is not always possible but stay on the travel lanes. We plant 20 row sections. Insecticide sprays are done by driving on those driveways. We either hand harvest into 5-gallon buckets or use a three-point hitch sweet corn picker. Other times of the year when timing isn't as critical say off when it is wet. Sometimes there will be marginal soil conditions at planting time. I have found after no-tilling and using cover crops for several years you can smear a crop in if you need to and get away with it. However, it is not the best idea, but you need to do what you need to do. When planting into wet conditions reduce your down pressure to a minimum and lighten the weight in your planter as much as possible. 2018 and 2019 were extremely wet years and it didn't seem to matter if you no-tilled or tilled the soil stayed saturated nearly all season and much of the corn suffered as a result.

Planter attachments
There are all kinds of attachments that can be added to planters to improve their performance. I started with a 4-row wide conventional John Deere 7000 with no coulters in the fall of 2001. That winter I added a heavy-duty spring kit to each row unit which allows me manually to adjust the down pressure on the row unit. I then added a Yetter, unit mounted 13 wave coulters and a Yetter finger row cleaner to each row unit, lastly, I added Keeton seed firmers to each seed tube. I no-tilled successfully for about 5 years that way. Then I wanted to make a few more improvements. The dry fertilizer double disk openers wouldn't get the starter fertilizer in the ground deep enough to really benefit the seedling. I took them off and added a 50-gallon liquid tank in the middle of the planter and totally tubular to dribble 5 gallons of liquid starter per acre in the seed trench. At that time, I also replaced the seed disks and converted 2 rows of the planter with reduced inner diameter gauge wheels and spiked closing wheels along with a drag chain. I have not converted the whole planter to reduced inner diameter gauge wheels and drag chains because I have not seen a visible emergence and/or yield advantage to the rows without them. At that time, we used bedded pack ma-

nure on some fields and I liked the row cleaners to move the clumps of manure out of the way. My row cleaners are not the floating type, I need to manually set them at a fixed position.

No-till requires a change of your mind set. You don't need to have a field that is moldboard plowed, disced and cultipacked to plant a sweet corn crop. I would argue my no-till fields do as well or better than those that are tilled in my area. If you are not going do continuous no-till, I feel you might as well just keep tilling. The real benefits of no-till take a few years to be visible. I remember the first few years into no-tilling I couldn't get the planter in the ground. The soil had dried out and became hard as a rock. Now with our organic matter increasing and using cover crops every year the ground has become much more mellow. However, that nice mellow ground if left uncovered over the winter will erode, so it needs to be protected with cover crops and crop residue.

We haven't sold the moldboard plow, chisel plow, disk or cultipacker. They are used very little anymore, only to prepare the ground for plastic to grow the other vegetables. Maybe someday I will no-till them too, but until then we will keep the tillage equipment around, besides they aren't worth much anyway!

HIGH HEAT AND SWEET CORN QUALITY

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In 2021 sweet corn growers throughout the region experienced quality problems in sweet corn related to poor pollination because of high heat. This problem is more severe in less stress tolerant varieties and where irrigation is inadequate.

In corn, silk elongation begins 7 to 10 days prior to silk emergence from the husk. Every potential kernel (ovule) on an ear develops its own silk that must be pollinated for the ovary to be fertilized and develop into a kernel. The silks from near the base of the ear emerge first and those from the tip appear last. Under good conditions, all silks for an ear will emerge and be ready for pollination within a span of 3 to 5 days and this usually provides adequate time for all silks to be pollinated before pollen shed ceases.

Pollen grains are borne in anthers, each of which contains a large number of pollen grains. The anthers open and the pollen grains pour out after dew has dried off the tassels. Pollen is light and can be carried considerable distances (up to 600 feet) by the wind. However, most of it settles within 20 to 50 feet. Pollen shed is not a continuous process. It stops when the tassel is too wet or too dry and begins again when temperature conditions are favorable.

Leaf scald affecting sweet corn husks.

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

Under favorable conditions, a pollen grain upon landing on a receptive silk will develop a pollen tube containing the male genetic material, develop and grow inside the silk, and fertilize the female ovary within 24 hours. The amount of pollen is rarely a cause of poor kernel set. Each tassel contains from 2 to 5 million pollen grains, which translates to 2,000 to 5,000 pollen grains produced for each silk of the ear shoot.

Poor seed set is often associated with poor timing of pollen shed with silk emergence. If silks emerge after pollen shed poor seed set will result. Shortages of pollen are usually only a problem under conditions of extreme heat and drought. Extreme heat and desiccating winds can affect pollen germination on silks or pollen tube development leading to poor seed set. Insects that clip silks during pollination can cause similar problems.

Leaf and husk scald was also found in some sweet corn crops in 2021. Leaf or husk scald is a physiological disorder similar to necrotic sunburn in fruits and vegetables. It occurs when leaf or husk temperatures rise above a critical level and cells die rapidly, leaving a bleached white appearance. While newly emerged leaves in the upper canopy of susceptible varieties that are the most exposed are the most likely to scald, some of the leaf scald can progress deeper into the canopy showing up on some of the corn husks, which will affect marketability. Leaf scald occurs most commonly when temperatures are in the high 90s or over 100, skies are clear (high solar radiation), and humidity is low. While effect on yield is usually minimal, leaf scorch at the ear leaf level can affect kernel fill.

Leaf scald has a genetic component as certain varieties of sweet corn are more susceptible. Overhead irrigation during high temperature hours can reduce this disorder.

HISTORY AND PROJECTIONS OF INSECT POPULATIONS, INSECTICIDES, AND PESTWATCH MONITORING

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Insects can infest sweet corn during seed-germination, vegetative, taseling, silking, and ear-fill stages. Pest populations, risk of damage, and insecticide options have changed over the last few decades.

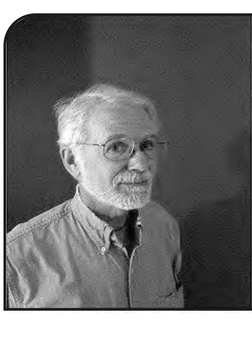
Pest populations are changing due to the influence of genetically engineered crops, climate change, and resistance. The most dramatic change has been the decline of European corn borer (ECB) due to the adoption and efficacy of GE crops. Bt-field corn became available in 1996, and ECB was the prime target. Adoption rates have approached saturation, and efficacy against ECB is very high. Widescale adoption, plus repeated use, has driven ECB populations to historic lows. Areawide ECB decline is well documented throughout much of the U.S. The economic benefit of areawide reductions accrues to both those who adopt the technology, and to those who do not. Non-adopters obtain a larger economic boost because they do not absorb the additional seed costs. GE crops today include cotton, maize, potato, soybean, eggplant, rice, papaya, cowpea, and squash; potential commercial lines also exist for broccoli and plum. Target pests include species of moths and beetles and will probably expand to true bugs and thrips, and current options control aphid-transmitted viruses in squash, papaya, and possibly plum and potato.

Resistance and climate are affecting corn earworm (CEW) populations. Although Bt crops can slow corn CEW development, CEW was not the prime target, efficacy was lower, and resistance to some Cry proteins is now prevalent. However, cultivars with vegetative insecticidal proteins (called Vips), such as Remedy or other Attribute II lines, are highly effective. Also, CEW has resistance to pyrethroids. We tend to see the degree of resistance starting off low and increasing seasonally. One hypothesis is that the resistant individuals are less able to overwinter, and thus we see a lower fraction of resistant individuals early in the season, but this fraction increases as they are more likely to survive pyrethroid applications. Overwintering success is influenced by climate change. Historically, zero, or a very small (<1) percent of the pupa successfully overwinter in the soil in PA, in the southeast corner of the state. However, overwintering is occurring in MD, DE, and NJ. Presumably, we also have overwintering at higher rates in closer locations to the south, and more or earlier dates for migratory flight. These night-flying moths fly when evening temperatures exceed 55 F, and climate models project temperature increases will be more during the night.

Fall armyworm (FAW) was also not a prime target of GE crops, and populations are dependent on migration from where hosts are continuously available, such as Florida and southern Texas. Populations also show resistance to pyrethroids and Bt constructs. We saw historically high populations in our area this past year, 2021.

Another night-flying moth, the Western bean cutworm, is expanding its range from the Great Plains, into the Midwest, nearby Canada, and western PA. This moth can damage mid to late season sweet corn. A related species, the yellow striped armyworm (YSAW), used to be a relatively rare occurrence in PA, but is now more common, and reached field-scale defoliation levels in potato in 2020. YSAW has a very large host range.

Monitoring has focused on the timing and intensity of the flight of these night-flying moths, estimated from traps baited with sex-pheromone lures. The Pennsylvania Vegetable Grower's Association, in collaboration with Penn State Extension, has been supporting this effort continuously since the late 1990s. PestWatch is a web-mapping soft-



Dr. Fleischer is in the Department of Entomology at The Pennsylvania State University where he specializes in insect population dynamics. He has been worked in vegetable agroecosystems for 30 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.

ware platform for visualizing trap catch data. Users can initialize a site and enter and edit trap catch values at that site. Data are updated nightly, and running weekly averages are mapped and hyperlinked to time series graphics at that site. In PA, there have been about 15 to 20 sites, with 2 to 4 species being monitoring per site, each year. The current software exists within Penn State's Center for Environmental Informatics, but changes in server and staff hobbled the databasing portion of PestWatch in 2021. This is be rectified through a collaboration with Penn State's Research Innovations with Scientists and Engineers (RISE) program and the Southern IPM Center. W plan to have a new PestWatch for 2022 with the same visualizations but renovated databasing.

Early season. Neonicotinoid came available in about 1996. Several are now used to treat seed, which protects against corn flea beetle, which vector a bacterial disease (Stewart's wilt). Host plant resistance has also contributed to reducing risk from Stewart's wilt.

Main season. From vegetative through ear-fill, the primary pests continues to be the larvae ('worms') from night flying moths. By the mid 1990's, pyrethroids (IRAC group 3) were commonly used along with organophosphates or carbamates (IRAC group 1) as foliar sprays. Today, several IRAC group 1 options are no longer available, and we have a much wider array of modes-of-action. Relevant to sweet corn, along with the seed treatments, foliar options include neonicotinioids (Group 4A and 4D), diamides (Group 28), miticides (Group 23), a wider array of pyrethroids (Group 3A), and premixes. We also have transgenic Bt cultivars that provide host plant resistance. These all tend to provide improved farm-worker safety.

Bees and beneficials. Honeybees and other bee species collect corn pollen, and concerns about declining bee populations have risen dramatically. This has led to label restrictions and bee-toxicity rankings (bee TR). Although bee TR are based on acute toxicity to only honeybees, they are a start to conserving bees. In the past, all insecticide options had a high bee TR, but today we have insecticides in IRAC class 28 - the diamides - that have a low bee TR. Diamides include the active ingredient chlorantraniliprole in Coragen and Vantacor. Vantacor has some smaller packaging options that may make it more affordable to adopt. Although some OCIA-labeled spinosyns (IRAC class 5 - e.g., Blackhawk, Entrust) are sometimes considered having a medium bee TR, these are highly toxic to bees for 3 hours post-treatment. Although most neonicotinoids are highly toxic to bees, one (acetamiprid, Assail), is viewed as having a medium bee TR.

Both diamides and spinosyns tend to be relatively safe for generalist predators (ladybird beetles, syrphid fly larvae, green lacewings, big-eyed bugs, minute pirate bugs, and others) that can be abundant in sweet corn. These predators do a good job keeping corn leaf aphids below damaging levels. Avoiding pyrethroids by using diamides, spinosyns, Bt cultivars with the Vip trait tends to prevent corn leaf aphids reaching damaging levels. If foliar sprays are needed for corn leaf aphid, a newer option in a subclass of neonics (Sivanto, IRAC class 4D) is listed with medium bee TR. Although it is highly toxic to leaf-cutting bees, it is less toxic to honeybees and bumble bees.

Bt-sweet corn. The most efficacious way, by far, to conserve bees and generalist predators, while still controlling worms, is to use Bt-cultivars. These rely on insecticidal proteins – either as crystals (termed Cry proteins) during sporulation, or as soluble proteins during vegetative growth (termed Vips, for vegetative insecticidal proteins). Sprayable options have been used for over 70 years but foliar Bt sprays in sweet corn tends not to be efficacious unless you inject the material into the silk tube, because the larva needs to ingest the protein. The initial Bt-cultivars in sweet corn relied on Cry1Ab, and later included Cry1A.105 and Cry2Ab2, but CEW now has resistance to these Cry proteins. However, some cultivars (e.g., Remedy) includes Vip3A, which is highly effective. In trials using a mid-June planting with no insecticides at Rock Springs in 2021, the Remedy cultivar resulted in 99.5% clean ears, compared to 26% clean ears in the isoline. Similar dramatic results were reported from 52 trials across a large geographic area, organized by Galen Dively. Bt-cultivars may also have herbicide tolerance.

Silk feeding, sap beetles, and new pests. Although the more selective options work well, they do not control silk-feeding beetles (Japanese beetle, adult stages of corn rootworms), sap beetles, or Brown Marmorated Stink Bug. Options for these revert to broad spectrum pyrethroids. Some premixes (Beseige, Elevest) include a pyrethroid plus chlorantraniliprole. Preventing sap beetles to build up by clean harvest of anything that provides sugar (such as strawberries, melons) is important for sap beetle management. Careful scouting can help limit when sprays are needed for silk-feeding beetles.

EAR INSECT PROTECTION IN SWEET CORN

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The most important and reliable pest of sweet corn in the mid-Atlantic is the corn earworm, Helicoverpa zea. Corn earworm overwinters in Delaware and Maryland, and possibly up to the Pennsylvania border in mild years. Its first generations feed on weeds or in corn whorls. In Delaware, we typically see an early June flight which coincides with the earliest corn beginning to silk. Moth counts are typically low in July before peaking in August and early September. Silk stage sweet corn is the most attractive for female moths to fly in to lay eggs. Eggs hatch in 2-3 days, depending on temperature, thus treatments should be initiated 1-3 days after first silk. Once larvae move into the silk channel, they are protected from insecticides. This necessitates frequent application of fast acting insecticides to protect growing silks and renew the protective barrier on the silks from worms. While there are other occasional pests that can cause damage to sweet corn (Stink bugs, sap beetles, corn leaf aphids, European corn borer, and fall armyworm) this presentation will focus on corn earworm management considerations, with notes on other pests.

The most common insecticide mode of action used for CEW management is the pyrethroid class. Between 2007 and 2008, earworms developed widespread resistance to pyrethroids. Pyrethroid resistance monitoring using adult vial bioassays reveal that pyrethroid susceptibility generally is greatest in June but resistance climbs rapidly in July (Fig. 1). This pattern was not as clear in 2020, suggesting that weather conditions can influence early season susceptibility.

Figure 1. Moth survivorship from an adult vial bioassay test with cypermethrin. Surviving moths can fly after 24 hour exposure to cypermethrin, indicative of general pyrethroid resistance.

The University of Delaware recommends using a wire cone trap with the following spray interval based on pheromone trap. These intervals are conservative, especially in the early to mid season. If the daily high temperature is above 80°F, and the corn is in the first 10 days of silking, spray schedules should be tightened by one day (ex. using a 2 day spray schedule instead of a 3 day spray schedule with high moth count) because eggs hatch quicker. This was tested in a 2018 August spray trail and a tighter interval resulted in an 11 point difference in clean ears when plots were treated with Warrior II.

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In 2020 and 2021, efficacy trials were conducted in the mid-Atlantic evaluating efficacy of individual pyrethroids alone and in combination with other modes of action. Spray trials conducted in early July generally result in relatively low levels of damage in untreated check plots and limited treatment differences. Efficacy differences are most pronounced in August-September spray trials. Between 2019-2021, individual pyrethroids have been evaluated for differences in efficacy when applied alone. There appear to be geographic and temporal performance differences as well as differences among pyrethroids, and data from Virginia Tech trials and Delaware trials will be discussed. Hero, a mixture of two pyrethroids, performed better in trials than other pyrethroids (Fig. 3). In 2021, a mixture trial was conducted combining 2 and 3 pyrethroids in a single application, but with limited if any improvement (Fig. 4). In some trials, beta-cyfluthrin performed better than bifenthrin and lambda-cyhalothrin, while in other tests is near equivalent. Besiege and Elevest/pyrethroid rotations provide greater, more consistent protection, highlighting the critical importance of the diamide component in spray trials. The spinosyn class (Radiant, Blackhawk, Entrust, Intrepid Edge premix) has performed well when mixed with a pyrethroid, but is inconsistent when used alone (Fig. 3). Several programs were tested in 2021 that incorporated multiple modes of action; they performed as well as a simplified Besiege or Elevest alternation with a pyrethroid. There generally is not a great difference in ear protection between Besiege and Elevest, but the bifenthrin component of Elevest may provide slightly greater protection against stink bug. Please note that the chlorantraniliprole component of both products and also of Vantacor has a maximum a.i. use rate per crop which limits the applicator to 3-4 applications, depending on the rate selected. This needs to be carefully considered if making a pre-silk worm application.

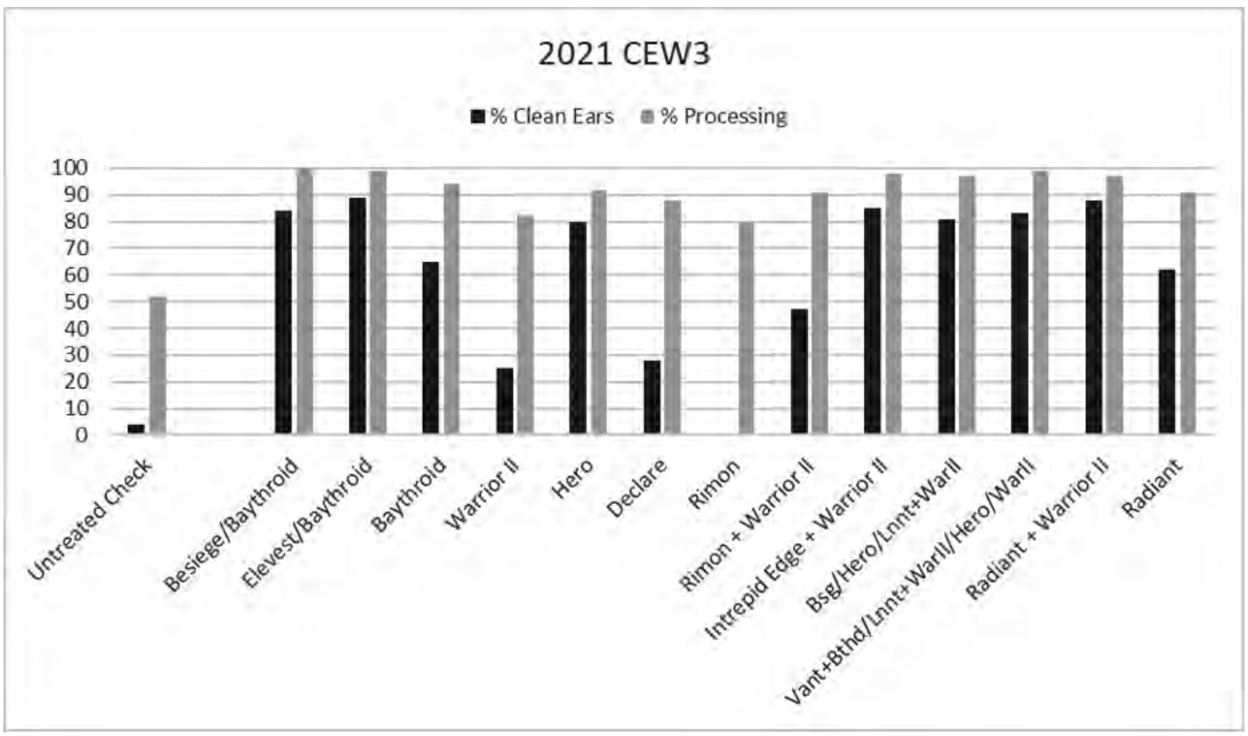

Figure 3. August 2021 spray trial % clean ears and % processing quality ears (ears with some tip damage).

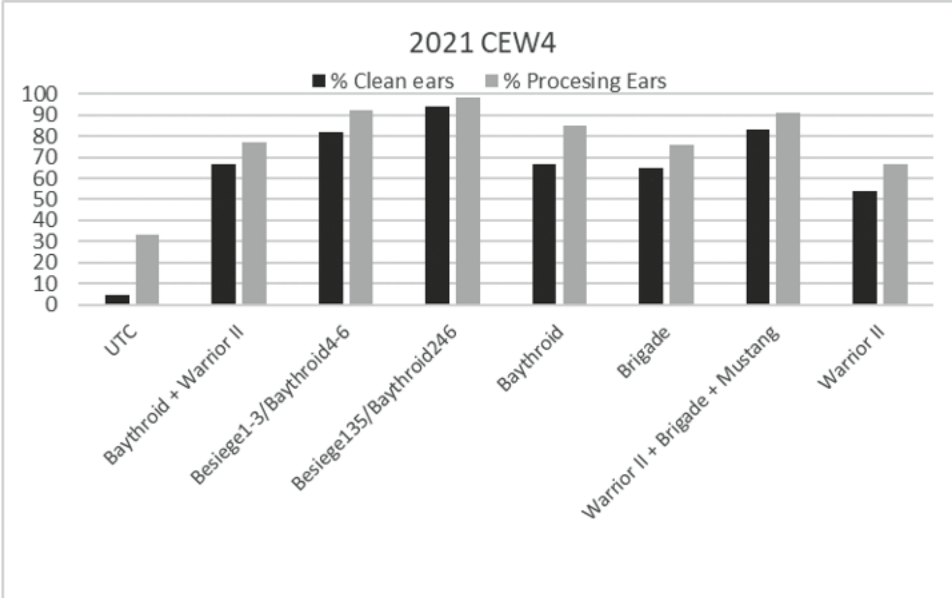

Figure 4. August-September 2021 spray trial % clean ears and % processing quality ears (ears with some tip damage).

Bt resistance has been monitored for over several years through a sentinel plot network maintained by Dr. Galen Dively at the University of Maryland. The only trait package that provides near total ear protection is Attribute II and Attribute Plus containing the Vip3A gene. A trait table with Vip varieties can be found https://agrilife.org/lubbock/files/2020/02/2020_BtTrai_Table_Sweet.pdf. All other trait packages should be treated as susceptible sweet corn (Fig. 5).

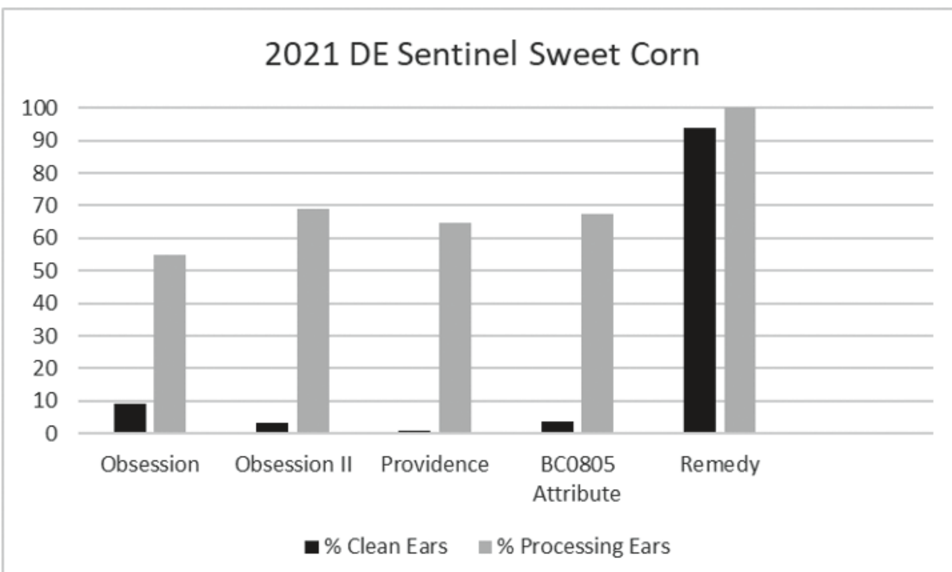

Figure 5. Delaware 2021 sentinel Bt resistance plot. The only injury in the Remedy (Attribute II) sweet corn was minor tip damage from a first or second instar larva. No live larvae were found in ears.

Sap beetle damage generally tracks treatment CEW efficacy. Sap beetles generally start to come to ears after full silk, at which point pyrethroids should be used (Fig. 6). Soft chemistry may be an option for the first 1-2 applications, especially if honeybees are present on-farm or nearby. On-farm sanitation is critical to reduce sap beetle populations, including timely crop destruction and incorporation and composting cull fruit.

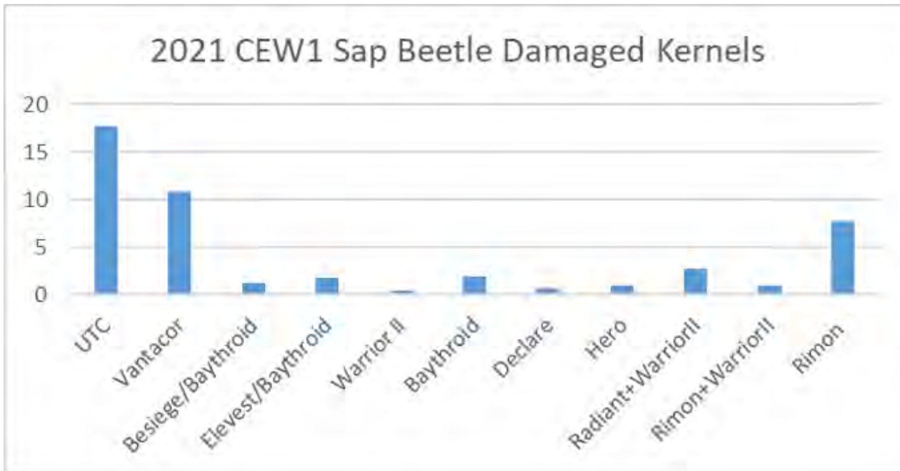

Figure 6. Number of sap beetle damaged kernels per treatment.

BEST OF THE PENN STATE FLOWER TRIALS 2021

Ageratum 2 cultivars

Best performance:	Artist Blue-Proven Winners

Angelonia 19 cultivars

Best performance:	Archangel Purple Improved-Ball FloraPlant
	AngelMist Spreading Dark Purple IMP-Ball FloraPlant
	AngelMist Spreading White-Ball FloraPlant
	Aria Soft Pink-Dummen Orange
	Angelissa White-Sakata Seed America
	AngelMist Spreading Pink IMP-Ball FloraPlant
	Aria Blue-Dummen Orange
	Archangel Coral-Ball FloraPlant
	Archangel White-Ball FloraPlant
	Aria White-Dummen Orange

Begonia 82 cultivars

Best performance:	Viking Explorer Rose on Green-Sakata Seed America
	Viking Explorer Red on Green-Sakata Seed America
	Big Pink Green Leaf-Benary
	Big Red Bronze Leaf-Benary
	Big Red Green Leaf-Benary
	Big Rose Bronze Leaf-Benary
	Big White Green Leaf-Benary
	Bowler Bronze Leaf White-Syngenta Flowers
	F1 Fiona Pink-American Takii
	F1 Fiona Red-American Takii
	F1 Fiona Rose-American Takii
	F1 Fiona White-American Takii

Sinclair Adam has received a BS from the Univ. of Wyoming in Plant and Soil Science 1983, and a MS from the Univ. of Vermont in Plant and Soil Science 1988. He is an Extension Educator in Floriculture with Penn State Extension, based in Lebanon County PA, and Flower Trial Director since 2013. He has been in education at Univ. of Vermont (Adjunct) 2013, Temple University (Adjunct & Senior Lecturer) 2000-2006, & Temple University Research Fellow 2002-2006. Sinclair has over 30 years industry experience: Recently, as Plant Scientist, for Vermont Organics Reclamation, and owner, of Dunvegan Nursery from 1989-2009. Sinclair has been published in research on The Penn State Flower Trials, as well as on plant propagation, nitrogen nutrition of perennial plants, stock plant management, germplasm releases from 1990-2013 in ASHS proceedings, Journal of Environ Hort, HortScience, Perennial Plant Assn. Journal, Daylily journal, IPPS proceedings, and American Nurseryman. He has been an invited speaker at Penn State Seminar series, The Western Pa Greenhouse Conference, Mifflinberg Central Greenhouse Meeting, Mid-Atlantic fruit & Vegetable Conference, Lancaster Agricultural Industry Conference, the VT Flower Show, Univ. of VT, Perennial Plant Association, Northern New England Nursery Conference, Millersville Native Plant Conference, US Nat'l Arboretum. Lahr Conference, New England Greenhouse Conference, and International Plant Propagators Society. Holder of 15 plant patents, Sinclair has developed Tiarella, Chrysanthemum, and Phlox selections for industry, and is a member of ASHS, PPA, IPPS, & Pi Alpha XI.

	Jurassic Pink Splash-Ball Ingenuity
	Jurassic Dino Black Sky-Ball Ingenuity
	Jurassic Dino Polka Dot-Ball Ingenuity
	Jurassic Jr. Berry Swirl-Ball Ingenuity
	Jurassic Jr. Red Splash-Ball Ingenuity
	Jurassic Megalo Croc-Ball Ingenuity
	Jurassic Megalo Reptile-Ball Ingenuity
	Tophat Pink-Syngenta Flowers
	Tophat Rose Bicolor-Syngenta Flowers
	Tophat White-Syngenta Flowers
Bidens 6 cultivars	
Best Performance:	Taka Tuka Orange Yellow Brush-Benary Plus
	Taka Tuka Red Yellow Brush-Benary Plus
	Tiger Bee-Kientzler North America
Bracteantha 1 cultivar:	Granvia Gold-Suntory Flowers
Caladium 5 cultivars	
Best Performance:	Hot 2 Trot-Classic Caladiums
	Xplosion-Classic Caladiums
	Ballet Slippers-Classic Caladiums
	Heart to Heart Splash of Wine-Proven Winners
Calibrachoa 37 cultivars	
Best performance:	Bloomtastic Yellow-Dummen Orange
	Cabaret Lavender IMP-Ball FloraPlant
	Cabaret Lemon Yellow IMP-Ball FloraPlant
	Cha Cha Diva Apricot-Ball FloraPlant
	Cha Cha Frosty Lemon-Ball FloraPlant
	Cha Cha Tangerine-Ball FloraPlant
	Conga Lavender-Ball FloraPlant
	Conga Red IMP-Ball FloraPlant
	MiniFamous Neo White 22-Selecta One
	MiniFamous Uno Yellow + Red Vein 22-Selecta One
	Ombre Blue-Danziger Flower Farm
	Ombre Pink-Danziger Flower Farm
	Ombre Yellow-Danziger Flower Farm
	Pocket Apricot Eye-Kientzler North America
	Pocket Blue-Kientzler North America
	Pocket Red-Kientzler North America
	Pocket White-Kientzler North America
	Rainbow Tiger Tail-Dummen Orange

Superbells Double Amber-Proven Winners
Superbells Double Twilight-Proven Winners
MiniFamous Neo Double PlumTastic-Selecta One

Calylophus 2 cultivars
Best Performance: Ladybird Sunglow-Proven Winners

Celosia 16 cultivars
Best Performance: Bright Sparks Bright Yellow-Syngenta Flowers
Bright Sparks Scarlet-Syngenta Flowers
Kelos Fire Orange-Beekenkamp Plants
Kelos Fire Scarlet-Beekenkamp Plants
Kelos Fire Red-Beekenkamp Plants
Kelos Candela Pink-Beekenkamp Plants
Kelos Fire Yellow-Beekenkamp Plants
Kelos Lunar CECR 2100 Pink-Beekenkamp Plants

Coleus 27 cultivars
Best Performance: 15-01-Kientzler North America
ColorBlaze El Brighto-Proven Winners
ColorBlaze Newly Noir-Proven Winners
ColorBlaze Torchlight-Proven Winners
Copperhead-Ball FloraPlant
Dragon Heart-Ball FloraPlant
Heartbreaker-Ball FloraPlant
FlameThrower Cajun Spice-Ball FloraPlant
FlameThrower Sriracha-Ball FloraPlant
Grape Expectation-Kientzler North America
Limewire-Ball FloraPlant
Main Street Yonge Street-Dummen Orange
Morning After-Kientzler North America
Spitfire-Ball FloraPlant
Tickled Red-Kientzler North America
Vulcan-Ball FloraPlant

Combinations 26 cultivars

Best Performance:
- Benary Mothers Mix-Benary Plus Benary Silver and Rose-Benary Plus
- Benary Soft and Fuzzy-Benary Plus
- Confetti Garden Endurable Beauty-Dummen Orange
- Confetti Garden Endurable Lilac-Dummen Orange
- Confetti Garden Lasting Love-Dummen Orange
- Confetti Garden Midnight-Dummen Orange
- MixMasters Oh Behave-Ball FloraPlant
- MixMasters Sunnyside IMP-Ball FloraPlant

Cuphea 1 cultivar
- Trixi Heartbeat-Selecta One

Cyperus 1 cultivar
- Trixi Wildberry 22-Selecta One

Dahlia 44 cultivars

Best performance:
- Honeybells-Ball FloraPlant
- Prince Tut-Proven Winners
- Dahlita White-Selecta One
- Darlin Burgundy Lace-Danziger
- Labella Maggiore Purple-Beekenkamp Plants

Evolvulus 2 cultivars

Best performance:
- Lubega Power Cherry Stripes-Benary Plus
- Lubega Power Red-Benary Plus

Exacum 2 cultivars

Best performance:
- Lubega Power Violet Bicolor-Benary Plus
- Blue My Mind-Proven Winners
- Blue My Mind XL-Proven Winners
- Jupiter White-Ball Ingenuity

Gaillardia 2 cultivars

Best performance:
- Heat it up Yellow-Proven Winners

Geranium (*Pelargonium*) Interspecific 7

Best performance:
- Calliope Medium Dark Red DL-Syngenta Flowers
- Calliope Medium Dark Red-Syngenta Flowers
- Mojo Dark Red-Syngenta Flowers
- Mojo Dark Pink-Syngenta Flowers
- Mojo Hot Cherry-Syngenta Flowers

Geranium (*Pelargonium*) Zonal 25 cultivars

Best performance:
- Starry Pure White-Syngenta Flowers
- Moonlight Orange-Selecta One
- Sunrise Rose+Big Eye-Selecta One
- Anne-JP Bartlett
- Emily-JP Bartlett
- Robin’s Rose 07355-JP Bartlett

Gomphrena 2 cultivars

Best performance:
- Truffula Pink-Proven Winners
- Cosmic Flair-Kientzler North America

Helianthus 2 cultivars

Best performance: Suncredible Saturn-Proven Winners

Heliotropium 1 cultivar Augusta Lavender-Proven Winners

Impatiens hybrida 12 cultivars

Best performance:

SunPatiens Compact Orchid Blush-Sakata Seed America
SunPatiens Compact Rose Glow-Sakata Seed America
SunPatiens Compact Deep Red-Sakata seed America
SunPatiens Compact Deep Red/White IMP-Sakata Seed America
SunPatiens Compact Happy Days (mix)-Sakata Seed America
SunPatiens Vigorous Sweetheart White-Sakata Seed America
Spectra Bright Red-Syngenta Flowers
Spectra Magenta-Syngenta Flowers
Spectra Orange-Syngenta Flowers
Spectra Pink-Syngenta Flowers
Spectra White-Syngenta Flowers

Impatiens New Guinea 43 cultivars

Best performance:

ColorPower Orange-Selecta One
ColorPower Peach Frost-Selecta One
ColorPower Red 22-Selecta One
ColorPower White 22-Selecta One
Paradise Electric Orange-Kientzler North America
Paradise New Red-Kientzler North America
Paradise Orange 2022-Kientzler North America
Paradise Orange Splash-Kientzler North America
Paradise Red IMP 31-Kientzler North America
Rococo Orange 2022-Kientzler North America
Rococo Purple 2022-Kientzler North America
Roller Coaster Tangy Taffy-Dummen Orange
SunStanding Apollo Cherry Red-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 Jazzy Blue Rose-Dummen Orange

Impatiens walleriana 27 cultivars

Best performance:

Beacon Coral-PanAmerican Seed
Beacon Salmon-PanAmerican Seed
Imara XDR Orange-Syngenta Flowers

	Imara XDR White-Syngenta Flowers
Lantana 27 cultivars	
Best performance:	Bandana Gold-Syngenta Flowers
	Bloomify Rose-Ball FloraPlant
	Bloomify Pink-Ball FloraPlant
	Bloomify Orange-Ball FloraPlant
	Bloomify Red-Ball FloraPlant
	Hot Blooded Red-Syngenta Flowers
	Little Lucky Lemon Cream IMP-Ball FloraPlant
	Little Lucky Red-Ball FloraPlant
	Lucky Peach-Ball FloraPlant
	Lucky Red-Ball FloraPlant
	Luscious Citron-Proven Winners
	Shamrock Orange Flame-Ball FloraPlant
	Shamrock Peach-Ball FloraPlant
	SunDance White-Sakata Seed America
	SunDance Yellow-Sakata Seed America
Lobelia 6 cultivars	
Best performance:	Magadi Compact Dark Blue-Selecta One
	Magadi Compact Blue + Eye-Selecta One
Lobularia 2 cultivars	
Best performance:	Violet Knight-Proven Winners
	White Knight-Proven Winners
Mandevillia 1 cultivar	Sun Parasol Sunbeam-Suntory Flowers
Marigold 9 cultivars	Endurance Yellow-Syngenta Flowers
Best performance:	Endurance Sunset Gold-Syngenta Flowers
	Endurance Orange-Syngenta Flowers
	Marvel II Gold-PanAmerican Seed
	Super Hero Deep Orange-Benary
Ocimum 3 cultivars	
Best performance:	Everleaf Emerald Towers-PanAmerican Seed
Ornamental Grasses 2 cultivars	
Best performance:	Buddy Blue-Benary
	Zora-Benary
O*steospermum* 4 cultivars	
Best performance:	4D White-Selecta One
	FlowerPower Compact Pink + Eye-Selecta One

Pentas 5 cultivars

Best performance: Graffiti 20/20 Cranberry-Benary
Starcluster Light Pink-Syngenta Light Pink Starcluster White IMP-Syngenta Flowers
Northern Lights Lavender-Benary

Pepper 2 cultivars

Best performance: Candy Cane Chocolate Cherry-PanAmerican Seed

Petunia 110 cultivars

Best performance: Itsy Magenta-Syngenta Flowers
Itsy White-Syngenta Flowers
Dekko Banana-Syngenta Flowers
Dekko Blue-Syngenta Flowers
Dekko Deep Lavender Vein-Syngenta Flowers
Dekko Red-Syngenta Flowers
Dekko Sorbet-Syngenta Flowers
Dekko Star Rose-Syngenta Flowers
Dekko White-Syngenta Flowers
SuperCal Premium Pearl White-Sakata Seed America
SuperCal Premium Yellow Sun-Sakata Seed America
SuperCal Premium Sunset Orange-Sakata Seed America
SuperCal Premium Purple Dawn-Sakata Seed America
ColorRush Merlot Star IMP-Ball FloraPlant
ColorRush Pink-Ball FloraPlant
ColorRush Pink Vein-Ball FloraPlant
ColorRush Purple-Ball FloraPlant
ColorRush White-Ball FloraPlant
Bees Knees-Ball FloraPlant
Cannonball White-Ball FloraPlant
E3 Easy Wave Pink Cosmo-PanAmerican Seed
F1 Trilogy Pink Lips-American Takii
Tea PETN 2089 Purple-Beekenkamp Plants
Tea PETN 2176 Indigo Vein-Beekenkamp Plants
Tea Purple Vein-Beekenkamp Plants
Tea Rose Morn-Beekenkamp Plants
Main Stage White 22-Selecta One
Durabloom Electric Lilac-Dummen Orange
Headliner Electric Purple 22-Selecta One
Headliner Enchanted Sky-Selecta One
Pretty Flora Mello Yellow-Ball Ingenuity
Sanguna Banana Candy-Syngenta Flowers
Shortcake Blueberry-Syngenta Flowers

	Supertunia Mini Vista Hot Pink-Proven Winners
	Supertunia Vista Snowdrift-Proven Winners
	Supertunia Royal Velvet-Proven Winners
	Supertunia Vista Bubblegum-Proven Winners
	Supertunia Vista Jazzberry-Proven Winners
	Supertunia Sharon-Proven Winners
	Supertunia Mini Vista White-Proven Winners
	Supertunia Priscilla IMP-Proven Winners
	Surfinia Purple Heart-Suntory Flowers
	Surfinia Heavenly Cabernet-Suntory Flowers
	TX-954-American Takii
	TX-987-American Takii
	TX-988-American Takii
Petunia Double 8 Cultivars	
Best performance:	Veranda Compact Double Sugar Plum-Kientzler North America
	Vogue Pink-Ball FloraPlant
Phlox 2 Cultivars:	
Best performance:	Gisele Red-Selecta One
Portulaca 6 cultivars:	
Best performance:	Sundial White IMP-Benary
Ptilotus 1 cultivar:	Joey Imp.-Benary
Rudbeckia x hybrida 3 cultivars	
Best performance:	Echibeckia Summerina Sunchaser-Pacific Plug and Liner
	Echibeckia Summerina Sunreef-Pacific Plug and Liner
Salvia 5 cultivars	
Best performance:	Unplugged Pink-Proven Winners
	Unplugged So Blue-Proven Winners
	Sallyfun Pure White-Danziger Flower Farm
	Sallyfun Deep Ocean-Danziger Flower Farm
Scaevola 4 cultivars	
Best performance:	Surdiva White Improved-Suntory Flowers
	Surdiva Blue Violet-Suntory Flowers
	Surdiva Fashion Pink-Suntory Flowers
	Blue Brilliance-Ball FloraPlant
Sedum 5 Cultivars	
Best performance:	Voodoo-Benary
	Oracle-Benary

Torenia 9 cultivars

Best performance: Vertigo Deep Blue-Ameriseed
Vertigo Magenta-Ameriseed
Hi-Lite Blue Jump Up-Syngenta Flowers

Verbena 26 cultivars

Best performance: Meteor Shower-Proven Winners
Lascar Mango Orange-Selecta One
Firehouse White-Ball FloraPlant
Lascar Vampire-Selecta One
Beats Purple + White-Selecta One
Beats Blue-Selecta One
Beats Red-Selecta One
Beats Red + White-Selecta One
EnduraScape Red IMP-Ball FloraPlant
Firehouse White IMP-Ball FloraPlant
Superbena Whiteout-Proven Winners

Vinca (Catharanthus) 14 cultivars

Best. performance: Soiree Kawaii Red Shades-Suntory Flowers
Soiree Kawaii White Peppermint-Suntory Flowers
Soiree Kawaii Coral Reef-Suntory Flowers
Soiree Kawaii Blueberry Kiss-Suntory Flowers
Volcano F1 Apricot-Cerny Seed
Volcano F1 Red-Cerny Seed
Volcano F1 Burgundy-Cerny Seed
Volcano F1 Polka-Cerny Seed

Zinnia 2 cultivars

Best performance: Profusion Red Yellow Bicolor-Sakata Seed America
Double Profusion Red-Sakata Seed America

MAJOR PESTS OF HERBACEOUS PERENNIALS

Stanton Gill, University of Maryland

In July of 2020, David Clement and I presented on some of the major insects and diseases of herbaceous perennials at Cultivate'20 Virtual. I'll give a short summary of a couple of the key insects here, and David Clement will cover some of the key diseases you should be monitoring for in your nursery and landscape, in a separate article.

First off, here's a good humor story involving perennials (a young worker at an herbaceous perennial nursery called in with this one): She was working on dividing perennials, and for entertainment, was listening to a podcast on her phone. During the podcast, the transmission started stuttering, with intermittent pauses. She pulled her phone out of her pocket and found a garden slug was gliding over the touch screen part of the screen, leaving a slime trail. She wiped off the slime, along with the slug, and the podcast immediately stopped stuttering. Something in the slug slime or the slug on the screen was interfering with the touch screen and the podcast transmission. It goes to show that bugs and arthropods affect our perennial growers in many ways.

Fern pests

One of the popular herbaceous perennials grown in nurseries and used in shady landscapes are native ferns. One of the major insects that's become established across the middle and eastern part of the United States IS a pest of the beloved ferns group—a moth in the Crambidae family. This moth is commonly called the leaf folder caterpillar (Herpetogramrna theseusalis). It's found in North America where it's been recorded from Alabama; Florida;

Maine; Maryland: North Carolina; Quebec, Canada; South Carolina; Texas: and Virginia.

The leaf folder caterpillar damages several native species of ferns—we've found it damaging sensitive fem, marsh fem, royal fem, Interrupted fem and shielded fern in Maryland. The caterpillar has been recorded in the south on Lorinseria areolata, the netted chain fem, native to eastern North America.

Adults are active and on wing from April to September in Maryland. The moth is a night flyer. If you walk through infested ferns in the daylight, the moth will fly up, zig-zag back and forth, and dive into foliage rapidly. You can catch them with a small sweep net.

Adults deposit eggs onto the fem foliage. The caterpillar puts out silk from its mouth and webs the foliage of the fern together in a bizarre rectangular box shape. The leaves webbing together is almost attractive-looking. The larvae hides in the folded leafbox during the day and come out at night to feed on the foliage of the fern.

Back in 2010, when DuPont was developing chemicals for ornamental insect control, they funded a trial we conducted over two years in an herbaceous perennial nursery in Maryland. We were testing new systemic materials DuPont was bringing into the market. One was called Acelepryn; the other was a numbered compound, HGW86. which is now sold under the name Mainspring. (Both of these products are now distrib-uted by Syngenta company.) We tested both foliar and drench applications. The drench of HGW86 performed the best in controlling the larvae. One application gave us 10 to 12 weeks of control.

Fern scale

One of the most popular herbaceous perennials is liriope/mondo grass. It's been grown in greenhouses and nurseries for large landscape planting beds. The plants are adapted for uses in sun and partly shaded landscapes. One Of the big pests that plagues this plant is an armored scale that's commonly called the fern scale (Pinnaspis aspidistrae). It does get on ferns, as the com• mon name implies, but it's more commonly found on liriope/mondo.

It also infests other plants, including palms, bird of paradise, chamaedorea, chrysalidocarpus, dracaena, ficus, lady palm, monstera, ophiopogon, Phoenix roebelenii, staghorn fern and ti plant (Cordyline fruticosa). For most herbaceous perennial growers, this scale is mainly something to monitor for on liriope/mondo plants. As with most

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armored scale, it tends to blend in with the foliage Of the plant and goes undetected in the propagation stage, and once established in a growing area, is easily spread from plant to plant by the crawler stage.

Like most armored scale, the female gives birth under the cover that surrounds her body. Crawlers hatch from the eggs and eventually emerge from under the mother's armor. The crawlers move about until they begin to feed by inserting thread-like mouthparts into the leaf and sucking out nutrients. The Crawlers excrete wax to cover their body and remain immobile, feeding on the plant tissues.

The male feeds until the second instar stage, when it goes into a prepupal stage and then into the pupal stage. The male emerges as a small gnat—like insect, with one pair of wings, and often goes unnoticed. The female continues to feed into the mature third instar stage. The female mates with the winged adult male and the eggs mature inside the body of the female scale.

Multiple generations per year can occur, depending on location and growing conditions. Here in Maryland, outdoors, the scale has two generations per year.

The key with control is to monitor liriope/mondo regularly, looking for the sessile stages of the scale. If detected, several of the systemic insecticides can be used for control. Dinotefuran and Altus are two systemic insecticides that can be used. insect growth regulators Talus and Distance will work well if you can catch the scale at the crawler and first instar stage.

Ornamental grass scale
The last insect we'll cover is one that's being found on ornamental grasses. It's an armored scale we found in an herbaceous perennial nursery in Maryland in 2020 called Duplachionaspis divergens. It's from the Orient and doesn't have a recognized common name in America. This armored scale was first recorded in Florida and the U.S. from specimens collected on a grass in Sanford (Seminole County), Florida, on November 1, 2002 by Amanda Melco. However, a reexamination of specimens collected in Bradenton (Manatee County). Florida, on

Miscanthus sp. on September 6, 2000 by Mark Runnals is the earliest known record of this species occurring in Florida.

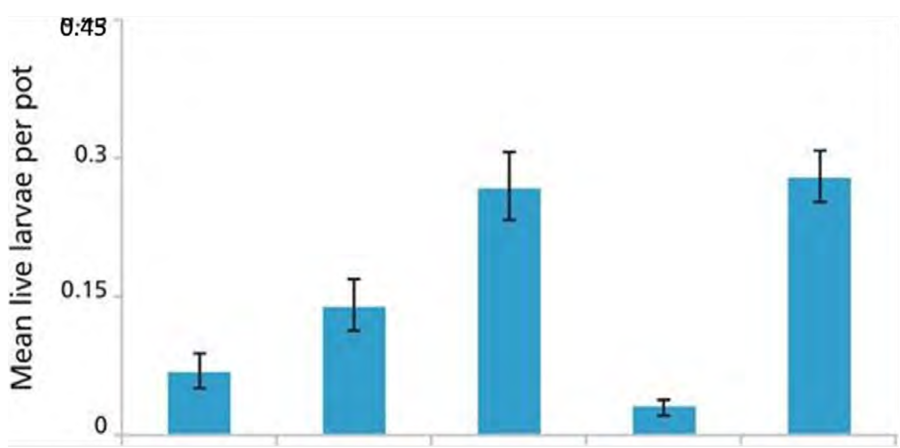
Here in Maryland, one of the professional IPM Scouts, Heather Zindash , found it on Acorus gramineus Variegatus in an herbaceous perennial nursery. It's been reported feeding on Miscanthus sinensis and pennisetum alopecuroides in the Midwest and Florida.

The armored scale Duplachionaspis divergens has a very noticeable white, elongated scale cover. By flipping the scale cover off, one can observe the body of the adult female, which is yellow in color with an elongated body shape. Little is known about the biology of this insect.

Regular monitoring and destroying of infested plants is the best course of action. The control methods mentioned under the fern scale should provide control if chemical treatments are needed.

Staying vigilant in a perennial nursery with a regular monitoring program as part of your IPM approach is the best course of action in catching these insects early and dealing with them before they become a major problem.

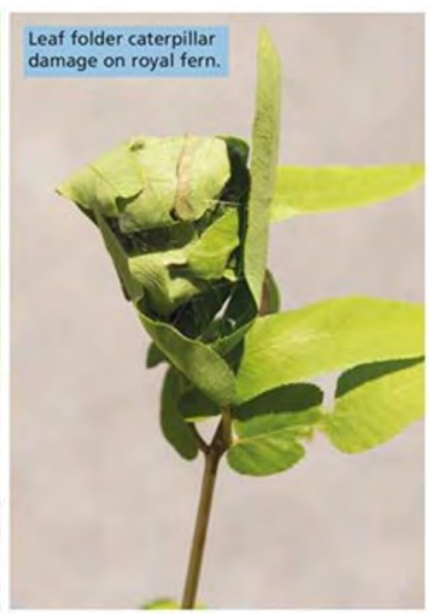
Figure 1: Live H. theseusalis per pot



Duplachionaspis divergens scale on *Acorus gramineus* Variegatus.

Fern scale on liriope.


Leaf folder caterpillar *(Herpetogramma theseusalis)* late instar larva.


Leaf folder caterpillar damage on royal fern.

ROOT OUT ROOT DISEASES — MANAGING HIDDEN DISEASES IN THE GREENHOUSE

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Both fungi and oomycetes (=water molds) can cause root and stem rot in the greenhouse. Some of the most common fungi causing root diseases are *Rhizoctonia solani, Berkeleyomyces basicola* (the old Thielaviopsis) and *Fusarium* species. In the oomycete category, watch out for *Pythium* and *Phytophthora*.

1. The FUNGI:

Fungi are filamentous organisms with chitin as their cell wall material. The ones causing plant root rot diseases are often able to live as saprophytes, feeding on dead organic material in between opportunities to attack crops. The ones we see the most often (Rhizoctonia and Fusarium) are common soil-dwelling organisms, so keeping them out of the greenhouse through sanitation practices is critical to disease prevention.

Rhizoctonia hosts include vinca, hedera, impatiens, New Guinea impatiens, mums, and lettuce. *Rhizoctonia* can cause damping off, cutting rot, stem cankers, root rot and aerial blight. The infected areas are usually tan to brown in color. Keeping field soil out of contact with the crop is important: practice careful sanitation. Biofungicides (such as *Trichoderma*-containing materials) may be used preventively. Fungicides such as 3336/6672 (Group 1, thiophanate methyl) or strobilurins (Group 11, such as Heritage or Empress) help to protect against Rhizoctonia, along with iprodione materials (e.g. Chipco 26019) or fludioxonil (Medallion).

Black root rot is caused by *Berkeleyomyces basicola* (syn. *Thielaviopsis basicola*). It has a narrower host range than Rhizoctonia, but can be very troublesome on pansies, calibrachoas, petunias, vinca of all kinds, poinsettia, rosemary and (hydroponic) basil. Look for irregular plant stands as a clue to an outbreak of black root rot, which you will most often notice if you have a high soil pH (pH 6.2 and higher). The disease is also favored by wet soil conditions. Fungus gnats often move this fungus around the greenhouse. Because the fungus forms chlamydospores that glom onto plastic, reuse of pots and flats from diseased crops requires a thorough power-wash and then disinfestation with materials such as ZeroTol, Physan 20 or a 1:9 dilution of bleach. Thiophanate-methyl (3336, 6672, etc.), is highly effective against black root rot but must be rotated with Affirm, Terraguard or Medallion.

Various **Fusarium diseases** affect roots of ornamental crops, especially if they are first stressed by over-fertilization. Often growers are troubled by host-specific Fusarium diseases that create a systemic and lethal infection of the xylem. Begonias are plagued by *Fusarium foetens*, mums by *Fusarium oxysporum* f. sp. *chrysanthemi* and cyclamen by *Fusarium oxysporum* f. sp. *cyclaminis*. *Fusarium* can be a problem on echeveria, lavender, and hosta. Anti-Fusarium management methods include keeping the pH high (over pH 6.2) and using calcium nitrate rather than ammonium nitrate; adequate calcium is important. Fungicides such as thiophanate methyl (FRAC Group 1) and azoxystrobin or pyraclostrobin (FRAC Group 11), fludioxonil (FRAC Group 12) and polyoxin D (Group 19) help to suppress Fusarium; Trichoderma spp. and other biocontrols can provide competition against the pathogen. Using resistant varieties is ideal for avoiding a Fusarium wilt disease. Drop troublesome cultivars!

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2. The OOMYCETES (Water Molds)

The water molds are closer relatives to algae than to fungi. Their life cycles are tied to an aquatic environment, so you will see them most often in hydroponic culture or in poorly-drained growing media. The zoospores made by Pythium and Phytophthora allow them to swim through the growing media in a container or between containers. Pythium and Phytophthora are the two most common oomycete genera; there are many different species of each which have different temperature and host preferences. Downy mildews are also oomycetes—we think of them as attacking foliage, but many of them can also infect through roots and become systemic.

Pythium root rot organisms are commonly found in field soil, so a grower's goal is to keep them from getting into the greenhouse. Many of the names of these pathogens have been changed recently, so don't be surprised to learn that your crop's root rot has been attributed to a *Globisporangium* instead of *Pythium*. Our previous *Pythium irregulare* and *Pythium ultimum* are now both *Globisporangium* species, just to keep us on our toes! Pythium is a common cause of damping-off, but will also attack root systems of mature plants, growing up into the stem to cause a black stem rot in some instances. Often Pythium root rot may cause quality losses rather than outright death of plants: infected plants can be smaller or off-color. One of the most damaging root rotters, *Pythium aphanidermatum*, affects chrysanthemums and poinsettias — beware of this summer-season *Pythium*, which functions well at 95-104°F. Pythium myriotylum is another one that likes it hot: 98-104°F. In contrast, *Globisporangium ultimum* is favored by 77-86°F, so it is more of a winter problem. With other common species, such as *Globisporangium irregulare* (favored by 86°F), frequently seen on geraniums, often the plants will not develop symptoms unless they are compromised in some way. Crops may become especially vulnerable if there is excessive fertilization or puddling around the containers. New Guinea impatiens are susceptible to *Globisporangium cryptoirregulare*, which can cause black stripes in roots and stems and wilting of all or part of the plant. Biocontrols often do a very good job countering *Pythium*. Effective fungicides are more limited for Pythium than other diseases. Mefenoxam is still very effective when the *Pythium* strain isn't resistant. Cyazofamid (Segway) has good effectiveness, as does etridiazole (in Truban and Terrazole). Although strobilurins work very well against Phytophthora, they are not top performers against *Pythium*.

Phytophthora root and crown rot is caused by organisms related to *Pythium*, but these water molds respond differently to certain fungicides. *Phytophthora nicotianae* is one that is seen often, across a range of greenhouse crops including azalea, gardenia, lavender, vinca, petunia, and pansy. Poinsettias have been harmed by P. *drechsleri*. For English ivy, P. tropicalis is a likely pathogen. Symptoms on infected plants are crown rot, root rot, stem cankers, and even a foliar blight. All of the fungicides used for Pythium will help against *Phytophthora*, and strobilurins are also very effective.

TOP PERFORMING PERENNIALS IN THE PENN STATE FLOWER TRIALS

1. Achillea Firefly Sunshine	Walters Gardens Inc.
2. Achillea Milly Rock Rose	Darwin Perennials
3. Achillea Ritzy Rose	Must Have Perennials
4. Allium Windy City	Intrinsic Perennial Gardens
5. Allium Purple One	Jelitto Perennial Seeds
6. Aubrieta Rock on Purple	Dummen Orange
7. Brunnera Alexandria	Terra Nova Nurseries
8. Brunnera Silver Heart	Plants Nouveau
9. Buddleja Butterfly Gold	Must Have Perennials
10. Coreopsis Limoncello	Dummen Orange
11. Coreopsis Fall Sensation 16-766	Dummen Orange
12. Coreopsis Fall Sensation Sunnyside	Dummen Orange
13. Coreopsis Fall Sensation Amber	Dummen Orange
14. Coreopsis Fall Sensation Vermillion	Dummen Orange
15. Delphinium Desante Blue	KieftSeed
16. Delphinium Delgenius	Pacific Plug and Liner
17. Dianthus Mountain Frost Ruby Snow	Darwin Perennials
18. Dianthus Mountain Frost Red Garnet	Darwin Perennials
19. Dianthus Mountain Frost Rose Bouquet	Darwin Perennials
20. Digitalis Pink Panther	American Takii
21. Delospermum Mountain Dew	Must Have Perennials
22. Echinacea Cara Mia	Terra Nova Nurseries
23. Echinacea Kismet White	Terra Nova Nurseries
24. Echinacea Lovely Lolly	Must Have Perennials
25. Echinacea Sombrero Poco Yellow	Darwin Perennials
26. Echinacea Moodz Dream	HilverdaFlorist
27. Echinacea Green Twister	Jelitto Perennial Seeds
28. Eupatorium Euphoria Ruby	Darwin Perennials
29. Fern Athyrium niponicum pictum Godzilla Painted Fern	Casa Flora
30. Fern Athyrium niponicum pictum Japanese Painted Fern Regal Red	Casa Flora
31. Fern Athyrium niponicum pictum Pearly White Painted Fern	Casa Flora
32. Fern Dryopteris pulcherrima Beautiful Wood Fern	Casa Flora
33. Gaillardia SpinTop Mariachi Copper Sun	Dummen Orange
34. Gaillardia Heat It Up Yellow	Proven Winners

Adam Sinclair has received a BS from the Univ. of Wyoming in Plant and Soil Science 1983, and a MS from the Univ. of Vermont in Plant and Soil Science 1988. He is an Extension Educator in Floriculture with Penn State Extension, based in Lebanon County PA, and Flower Trial Director since 2013. He has been in education at Univ. of Vermont (Adjunct) 2013, Temple University (Adjunct & Senior Lecturer) 2000-2006, & Temple University Research Fellow 2002-2006. Sinclair has over 30 years industry experience: Recently, as Plant Scientist, for Vermont Organics Reclamation, and owner, of Dunvegan Nursery from 1989-2009. Sinclair has been published in research on The Penn State Flower Trials, as well as on plant propagation, nitrogen nutrition of perennial plants, stock plant management, germplasm releases from 1990-2013 in ASHS proceedings, Journal of Environ Hort, HortScience, Perennial Plant Assn. Journal, Daylily journal, IPPS proceedings, and American Nurseryman. He has been an invited speaker at Penn State Seminar series, The Western Pa Greenhouse Conference, Mifflinberg Central Greenhouse Meeting, Mid-Atlantic fruit & Vegetable Conference, Lancaster Agricultural Industry Conference, the VT Flower Show, Univ. of VT, Perennial Plant Association, Northern New England Nursery Conference, Millersville Native Plant Conference, US Nat'l Arboretum. Lahr Conference, New England Greenhouse Conference, and International Plant Propagators Society. Holder of 15 plant patents, Sinclair has developed Tiarella, Chrysanthemum, and Phlox selections for industry, and is a member of ASHS, PPA, IPPS, & Pi Alpha XI.

35. Geum Tempo Yellow	Terra Nova Nurseries
36. Helenium Bandera	Plants Nouveau
37. Helenium Salsa	Plants Nouveau
38. Helenium HayDay Red Bicolor	Syngenta Flowers
39. Heliopsis Sole Scuro	Kientzler North America
40. Heliopsis Summer Eclipse	Darwin Perennials
41. Helianthus Suncatcher	Kientzler North America
42. Helleborus Ice & Roses Red	Skagit Horticulture
43. Heuchera Black Forest Cake	Terra Nova Nurseries
4. Heuchera Ruby Tuesday	Terra Nova Nurseries
45. Heuchera Dolce Wildberry	Walters Gardens Inc.
46. Heuchera Grande Black	Terra Nova Nurseries
47. XHeucherella Peach Tea	Terra Nova Nurseries
48. Hibiscus Summerific Evening Rose	Walters. Gardens Inc.
49. Hibiscus Summer Spice Plum Flambe	J. Berry Nursery
50. Leucanthemum Rebecca	Dummen Orange
51. Leucanthemum	Amazing Daisies Collection Proven Winners Banana Cream II Walters Gardens Inc.
52. Nepeta Blue Prelude	Darwin Perennials
53. Nepeta Cat's Pajamas	Walters Gardens Inc.
54. OG Pennisetum Yellow Ribbons	Intrinsic Perennial Gardens
55. OG Pennisetum Love and Rockets	Intrinsic Perennial Gardens
56. OG Pennisetum Pure Energy	Intrinsic Perennial Gardens
57. Rudbeckia American Goldrush	Intrinsic Perennial Gardens
58. Rudbeckia Glitters Like Gold	Intrinsic Perennial Gardens
59. Salvia Midnight Rose	Dummen Orange
60. Salvia Midnight Purple	Dummen Orange

LEAVE THOSE LEAVES ALONE — MANAGING FOLIAR DISEASES IN THE GREENHOUSE

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Diseases of foliage sneak up on you in the greenhouse. When environmental conditions shift, suddenly a disease that was hidden can become obvious and spread daily. Bacterial and fungal leaf spots, rusts, downy mildews, powdery mildews, foliar nematodes and viruses can all parasitize your crops—your goal is to protect them from this wide array of pathogens!

Bacterial Leaf Spots. Bacterial leaf spots resemble fungal leaf spots except that they often look water-soaked initially. They tend to have a yellow halo. Different species of *Xanthomonas* have troubled poinsettia and zinnia recently; Pseudomonas spots have appeared on brunnera and mums. For bacterial leaf spots, keeping foliage dry and rotating between copper materials and Bacillus biocontrols are the best solutions available. *Ralstonia solanacearum* Race 3, Biovar 2 causes a systemic bacterial wilt; it was seen on geraniums in 2020. Symptoms of *Ralstonia* resemble Pythium root rot: plants are wilted, stunted and die—but the whole plant doesn't wilt at once from Ralstonia blight. *Xanthomonas hortorum* pv. *pelargonii* causes bacterial blight of geraniums; it has been minimized by steps taken to manage *Ralstonia*: R3Bv2 is a Select Agent, subject to quarantine, because it endangers the potato crop.

Fungal Leaf Spots. Fungal leaf spots come in many different shapes and sizes, with different colored borders. Sometimes you will be able to see spore production, either as fuzz on the leaf or as spore containers that look like rounded grains of black pepper. *Cercospora*, *Botrytis*, *Myrothecium* and *Alternaria* spp. are some of the more common leaf spotting fungi. Recently Corynespora leaf spot has shown on poinsettia and hydrangea, and Stemphylium leaf spot on Kalanchoe. Avoid long leaf wetness periods! Monitor carefully and use systemic and contact fungicides to manage an outbreak. Fungicides such as chlorothalonil, mancozeb, copper and strobilurins (FRAC Group 11) are helpful, or FRAC Group 11 + 3 or 11 + 7 materials.

Rusts. Rusts are a subgroup of fungal diseases that are less frequently seen. The pustules by which they are identified are usually conspicuous on the underside of the leaf. Watch for rusts on chrysanthemums, roses, geraniums, mint and ornamental grasses. Effective fungicides include FRAC Group 11 (e.g. Heritage, Compass and Insignia) and mancozebs (FRAC Group M5).

Downy mildews. These diseases thrive in wet conditions. For some (e.g. impatiens downy mildew, the DM can form zoospores and these multiply its infection potential. Often cooler (spring and fall) conditions favor DMs but note that impatiens, sunflowers and rudbeckias can get DM all summer in irrigated or rainy gardens. Know which of your crops are prone to DMs and watch carefully for pale, vein-bounded leaf spots that turn brown over time. Remember that highly resistant impatiens may still get DM and use fungicides to protect them. Materials such as Segovis (FRAC Group 49) and Stature/Micora (FRAC Group 40) are especially strong against DMs; strobilurins (FRAC Group 11, e.g. Insignia, Compass, Heritage) are strong against certain DMs as are phosphorous acids (FRAC 33, Aliette, Alude etc). Among contact materials, mancozeb works very well while coppers are helpful.

Powdery Mildews. The PMs are another subgroup of fungal diseases. They spread by movement of conidia via air currents and cause white colonies or other symptoms. They build up to epiphytotics and are also to develop resis-

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tance to fungicides that have a single-site mode of action. Highly susceptible crops include begonia, calibrachoa, dahlia, gerbera, hydrangea, petunia, rose, rosemary, torenia, verbena, African violet, sedum, monarda, phlox, poinsettia, helianthemum, hemp, lettuce and strawberry. Beware of atypical symptoms: pale spots on leaves, leaf reddening, scabby or water-soaked spots, petal streaks, thin films of white. Any above-ground plant part can be infected. With verbenas, be alert to dead leaves at the base of the plant: check for PM—and spider mites—if you see these.

Fungicides for PM include two groups of strong systemics that are prone to resistance so they must be rotated with care: FRAC Group 11 (strobilurins such as Compass and Insignia) and FRAC Group 3 (DMIs such as Terraguard). There are also combination products: 11+ 7 and 11 + 3 in particular. Other options include pyriophenone (Seido, FRAC Group 50); thiophanate-methyl (FRAC Group 1); potassium bicarbonate (e.g. Milstop); coppers; sulfur; oils; biocontrols based on Trichoderma, Bacillus, or Streptomyces; or botanicals such as Regime, Regalia and EcoSwing.

Foliar nematodes. Foliar nematodes are not commonly seen in greenhouses today, although once problematic on begonias and certain foliage plants. They are a problem in herbaceous perennials grown outdoors. Symptoms are vein-bounded leaf spots, sometimes wedge-shaped, and sometimes distortion of the young leaves at the top of the plant. The leaf spots result from nematodes feeding inside the leaf after entering via the stomata, while the leaf distortion comes when nematodes feed from outside the leaf. Monitor nematode-prone plants for symptoms so they can be destroyed.

Viruses. There is no chemical therapy for plant viruses, although sometimes vectors of the virus can be controlled that way. The main greenhouse viruses are still the orthotospoviruses, Tomato spotted wilt virus (TSWV) & Impatiens necrotic wilt virus (INSV), plus Tomato chlorotic spot virus (TCSV) and Alstroemeria necrotic streak virus (ANSV). Controlling Western flower thrips is key to control ortho-tospoviruses. Watch for symptoms, anything from yellow ring spots to dead areas on stems. Keep thrips and weeds under tight control. Immunostrip tests can be used in-house to check suspicious plants.

GOING DOWN UNDER: A CLOSE UP LOOK AT INSECTS THAT DAMAGE ROOT SYSTEMS

Stanton Gill, Univ of Maryland

IPM Options For Root Aphis, Rhopalisphium Rufiabdominalis (Sasaki) And Root Mealybug, Rhizoecus Sp., In Production Nurseries And Evaluating New Insecticides.

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Root aphids are a rising problem in native plant nurseries, herbaceous perennial nurseries, aquatic plant nurseries and greenhouse growers growing field hemp stock and plug plants for transplanting for the rapidly expanding number of field hemp growers.

1 Due to Covid-19 social distance requirements, all counts were taken outdoors on a makeshift lab using dissecting scopes are all counts taken during trial.

Materials and Methods

We obtained 740 plants from a native plant nursery. We examined the root system of the 740 and narrowed the numbers down to 162 used in our trials. We selected plants with more than 2 to 3 aphids in the root zones. Some had as high as 30 -40 in root zones.

Stanton Gill, Regional Specialist (Professor Rank) with University of Maryland Cooperative Extension stationed at Central Maryland Research and Education Center. He is professor in the Landscape Technology Program at Montgomery College where he teaches 3 credit classes in Pest management, and greenhouse management at night. He writes, publishes and speakes across the US and internationally.

Precount: June 23, 2020
M-306 SE1 and MBI-203SC1 Treatments: June 23, June 30, July 7, and July 14, 2020; other treatments made only on June 23.

Material	Label Rate	Application Rate
Mainspring	8 oz/100 gal	.63 mL/L
Acelepryn	8 oz/100 gal	.63 mL/L
Endeavor	5 oz/100 gal	.37 g/ L
Endeavor	3 oz/ 100 gal	.22 g/L
Grandevo WDG	3 lbs/100 gal	3.6 g/L
Venerate XC	4 qts/100 gal	10 mL/L
M-306 SE1	6.4 fl oz/100 gal	0.5 mL/L
MBI-203SC1	2 qt/100 gal	5 mL/L
Beaveria bassiana		5 grams /500 ml
UTC		

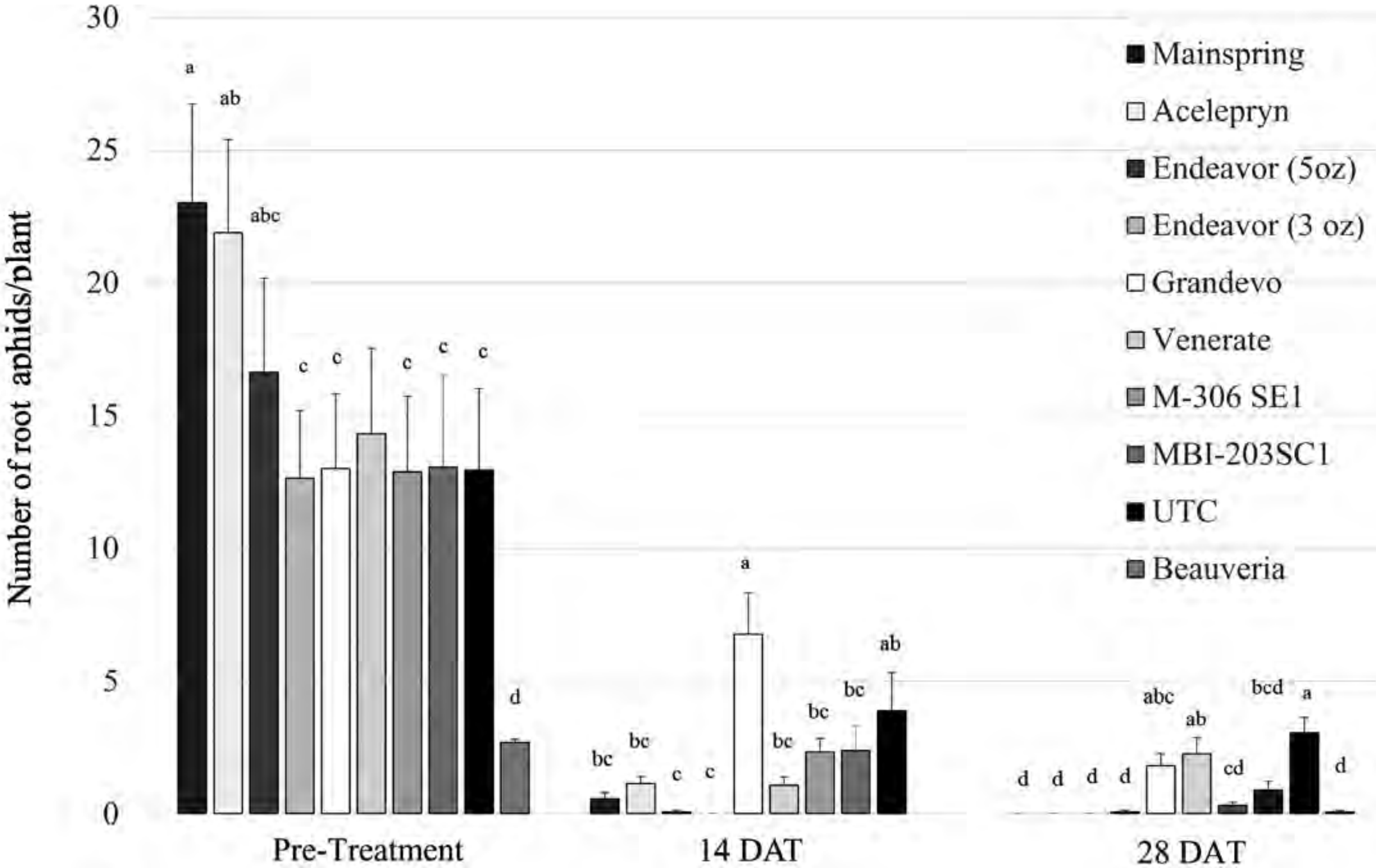
Applied again on June 30, 2020, July 7, July 14th

- Grandevo WDG - 3lbs/100 gallons - 3.6 grams/lite
- Venerate XC – 4qts/100 gallons – 10.0 milliliters/liter
- M-306 SE1 – 6.4 fl oz/100 gallons – 0.5 milliliters/liter
- MBI-203SC1 – 2 qt/100 gallons – 5 milliliters/liter

Measuring out each chemical using micropipet during Covid-19 epidemic

Post Counts: July 7 and July 21, 2020

Treatment	Pre	14 DAT	28 DAT	SE pre	SE 14	SE 28
Mainspring	23	0.5625	0	3.727153	0.223024	0
Acelepryn	21.875	1.125	0	3.506987	0.271953	0
Endeavor 5oz	16.625	0.0625	0	3.553021	0.0625	0
Endeavor (3 oz)	12.625	0	0.0625	2.554204	0	0.0625
Grandevo	13	6.75	1.8125	2.813657	1.566578	0.449247
Venerate	14.3125	1.0625	2.25	3.216777	0.322345	0.615765
M-306 SE1	12.875	2.3125	0.3125	2.854638	0.530085	0.119678
MBI-203SC1	13.0625	2.375	0.875	3.481461	0.934857	0.340037
UTC	12.9375	3.875	3.0625	3.067937	1.448778	0.558784
Beauveria	2.6875		0.0625	0.119678		0.0625



Roots Aphids 2020 Summary

- Populations of root aphids on plants used in the experiment declined greatly throughout the duration of the experiment.
- Although Mainspring, Acelepryn, and Endeavor treated plants started with populations as great or greater than untreated controls, by the end of the trial very few root aphids were found on those plants.
- We did not see significant reduction of aphid populations on Venerate, M-306 SE1, or MBI-203 SC1 plants until 28 DAT even though they had numerically fewer at 14 days.
- Grandevo did not work.
- Caution should be exercised when utilizing the data for substantial conclusions due to overall aphid decline throughout the trial. Decline seemed to "level-off" on untreated plants by the end of the experiment; however, this could have been due to the difficulty of finding the few on present on plants. A repeated study with greater populations on plants during the study would provide greater confidence in the results.
- Interesting to note the activity of mealybug destroyer, rove beetle and Hypoaspis miles mites feeding on root aphid

TERRA FARMS, A GROWER'S PERSPECTIVE ON PRODUCING AND MARKETING NATURALLY GROWN FRESH FARM CUT FLOWERS

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Is it possible to make six figures growing on a single acre of land? Legally? Yes. Cut flowers are one of the most profitable crops a farmer can grow. But there's a reason flowers come with those high margins. Growing beautiful cut flowers takes hard work and intense knowledge. Selling them is even harder.

Marketing Outlets

There are nearly as many ways to sell cut flowers as there are flower varieties. Many new farmers target the wholesale market, selling bulk stems directly to retail florists. It's the simplest method, but margins are lowest and competition is highest. The farmer must supply a reliable product at a reliable price. Branding is important as all that separates your flowers from the inexpensive importers is the "grown locally" label. Most often, the final customer has no idea where their flowers come from – local or not.

A higher-margin opportunity is to sell straight from the farm via a roadside stand or small market. This allows the farmer to have more freedom to grow what they want, when they want it. They also are not pressured to make regular deliveries. For farmers in a busy area, it can be a fine opportunity. But customers want a steady supply and seasonality means resetting the marketing push every spring as many once-loyal customers will fall out of their buying habit. For remote farms or those with strict zoning restrictions, this outlet may not be possible.

Direct-from-the-field sales with a value-added business attached acts as an ideal hybrid. While margins may be smaller than other direct-sales outlets, the branding opportunities can be rich. You must be a top-notch marketer dedicated to growing your business to make this approach work. But it can lead to a high-margin, scalable business. We use a pick-your-own model to bring customers to our field. From there, after seeing the operation, after talking with us and after enjoying our products firsthand, each customer goes home as a raving billboard for our business. It is our main form of marketing. All we have to do is get them to the field and our other value-added floral operations (wedding, bouquets, holiday décor and even farm merchandise) sells itself.

Marketing prowess is what must dictate each farm's approach. Those who aren't good at social media, web marketing and copy writing should focus on lower-margin, lower-risk approaches, while those blessed with marketing knowledge and experience can try higher-margin, higher-risk sales outlets.

Types of Flowers

Individual branding can dictate flower offerings to a degree. But, as with all enterprises, the customer truly dictates the market. Yes, it's possible to grow and sell all native varieties, but it will create a very small, niche market. Few brides, for instance, dream of carrying an all-native bouquet down the aisle. They want the most stylish and lush

Andy and Loni Snyder own Terra Farms, a small, 48-acre farm in southern York County, Pennsylvania. Andy is a full-time writer and marketing consultant with a Bachelor's Degree in English, from Millersville University and an MBA from York College. He grew up just a few miles from their farm. Loni is a full-time grower, florist, Instagram star, mother and teacher. She was born and raised in North Dakota. The two met while working at a remote fishing lodge in Southeast Alaska. They have two children.

flowers possible. And, as always, if your farm doesn't offer them, the South American exporters gladly do.

Some varieties we grow:

Snapdragons
Anemones
Dahlias
Sunflowers
Lisianthus
Zinnias
Ranunculus
Peonies
Tulips

Seasons

The downside of growing cut flowers in the Mid-Atlantic is seasonality. While greenhouses and high tunnels help to extend the season, offering on-farm sales (especially u-pick) is impossible throughout the winter months. It creates a seasonal business with an annual reset – an idea not unfamiliar to most of the region's produce growers.

It can be offset somewhat by focusing on key holidays (Valentine's Day, Mother's Day, Thanksgiving and Christmas). Seasonal planting and a concentration on key perennials focused on these key dates is important. For example, planting perennials that offer late-fall and early-winter greenery adds a helpful revenue boost late in the year. Tulips provide a quick flush of sales early in the spring.

Management

Operating a cut flower operation is extremely management intensive. It is a formidable barrier to entry. Lots of folks see the half-acre of field behind their house and dream of growing heaps of flowers. They can do it (and do it quite profitably), but they have to be committed to working very hard… all year long.

It is not unlike growing produce. But there are some critical extra steps. Many varieties require extensive staking. Post-season management of bulbs is also critical. It takes nearly a month to harvest, wash and split several thousand dahlia bulbs each fall. And, adding a pick-your-own operation magnifies the work. Now, not only do high-quality, pest-free flowers need to be grown, but the entire operation must be appealing (and safe) for the public. It often takes one employee just to maintain the property in a park-like setting.

Opportunities

The local flower movement is accelerating quickly. The consumer is learning that it is possible to grow a wide variety of cut flowers in the Mid-Atlantic region. It is creating strong, rather untapped markets. Large grocery chains are seeing the opportunity and are opening their supply chains to local operations, creating increased demand. Consumers are finally asking for local flowers.

Concerns

As demand for local flowers grows, so do the number of folks who want to grow local flowers. Many will succeed and many will fail. Overall, the market doesn't care; it searches for the best flowers at the best prices. Failing growers can wreak havoc on a local market as they desperately flood the region with underpriced stems. As industry popularity grows, it is a growing concern.

Flower farmers also have to deal with ever-increasing zoning issues. Traditional produce growers are clearly defined as agricultural entities. But many local government agencies (and even some federal ones) still don't automatically equate growing flowers with agriculture. For farms looking to bring consumers onto their property, this is an issue to consider. Always check local zoning before starting an enterprise.

USE OF SYSTEMIC INSECTICIDES COMBINED WITH BIOLOGICAL CONTROL

Adapted by
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The purpose of our field trials was to evaluate if the use of systemic insecticide drenches can be combined with release of insect predators and use of banker plants to deal with major insect and mite problems associated with growing dahlia plants. Thrips, aphids, Tetranychid mites, corn borers, and cucumber beetles are just a few of the pests that prefer to not share the dahlia flowers with growers. These plots were compared to plots treated with conventional chemical treatments.

Field trials were conducted in 2018 and 2019 to evaluate the use of low-risk systemic chemical applied as a soil drench combined with release of two predators to suppress damage from thrips. Results of this trial were published in GrowerTalks Magazine: Insects and IPM of Dahlias, March 2019 and Major Pests of Dahlias January 2021 by Stanton Gill, Extension Specialist in IPM for Greenhouses and Nursery, Central Maryland Research and Education center, University of Maryland Extension.

In each year, the goal was to keep insect and mite damage below a threshold that allowed the dahlia plants to produce flowers that would be used in dahlia judging events.

Two field test sites were used, one in Brookeville, Maryland (Heritage Roses) and the second in Damascus, Maryland (Crazy 4 Dahlias). The sites were monitored on a weekly basis by Heather Zindash (Independent IPM Scout) and Suzanne Klick (Lead Technician from CMREC University of Maryland facility). Each site had three plots. One with the systemic insecticide applied combined with the predator releases, a second plot in which the growers used conventional insecticide and miticide sprays, and a third plot that was an untreated control.

We decided on a combination of systemic chemical and biological control releases. Working closely with Nancy Rechcigl of Syngenta, Bell Nursery of Burtonsville, Jan Meneley of AgBio of Westminster, CO, and Koppert Company, we settled on Mainspring drenches applied twice during the year combined with predacious mite releases, banker plants, release of predacious insects, and pheromone and food baited sticky traps.

'Purple Flash' peppers were used as banker plants for *Orius insidiosus* (minute pirate bug), because of their continual blooming which provides pollen and nectar during the growing season.

On the systemic/biological control treated blocks, a soil drench of Mainspring at a rate of 8 oz/100 gallons of water was applied. Each plant was drenched at the base with 8 oz. (237 mL or .24 L) of prepared liquid solution.

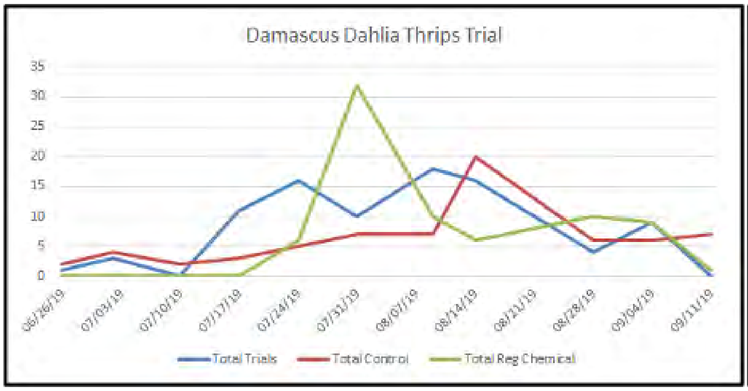
Mainspring™ GNL is a suspension concentrate (SC) formulation containing 1.67 pounds of cyantraniliprole per gallon. Cyantraniliprole belongs to the anthranilic diamide chemical class, introducing a new class of chemistry in

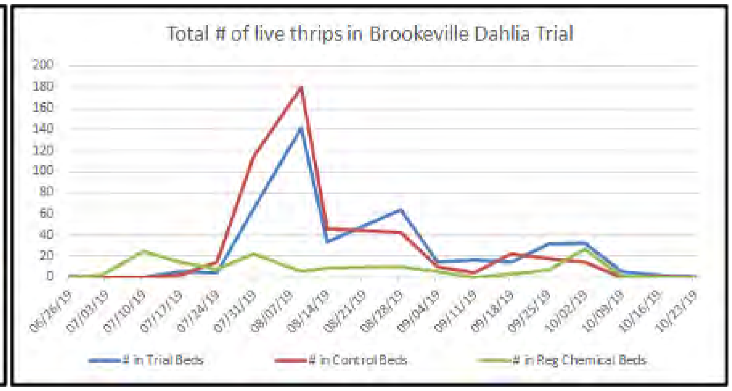
Heather Zindash is a Professional Integrated Pest Management (IPM) Scout & Consultant, a Certified Professional Horticulturalist, and an ISA Certified Arborist. Her company, The Soulful Gardener, helps growers, landscape professionals, commercial and residential property owners protect their plants by properly identifying pests and diseases and providing environmentally conscience management solutions.
Heather is a popular regional speaker who has lectured at numerous professional organizations, businesses, and special interest groups. She entertains and educates audiences with original photos, videos and stories based on personal experience, formal education, and specialized training.
She is also the President of The Maryland Bluebird Society, and Ladies in the Landscape, which supports women working in horticulture and related professions.

IRAC Group 28 to ornamental insect control. Mainspring quickly stops insect feeding after ingestion. It is compatible with many beneficial insects and mites.

We obtained Amblyseius cucumeris mites, a predatory mite that feeds on thrips nymphs. This species of thrips predatory mite has been used for prevention, control, and maintenance of various thrips species with good success in greenhouse operations. We purchased the mites under the name THRIPEX-PLUS from Koppert Biological Systems.

We applied two (2) 100 mL bottles containing 1,000 minute pirate bugs, sprinkled on each 'Purple Flash' pepper plant at both sites. They established well on the baker plants and were detected in the flowers of the dahlias shorty after release and were active throughout the rest of the season.





Data were collected every week to monitor effectiveness of treatment

Summary

Mainspring (cyantraniliprole) at 8 oz/100 gallons of water, applied as a soil drench, was excellent in controlling the aphids on the treated plants and provided control for the whole growing season in both 2018 and 2019. The Mainspring drench applications did not impact predator releases of the predacious mites or Orius released during our study. The dahlias in the biological control/systemic chemical control area had a greater number of blooms and thus had a slightly higher population of thrips in blooms. The thrips populations remained low on the conventional treated plants and the plants that were treated with chemical and biological control.

The banker plants did well and the Orius populations after the initial release remained active throughout the season.

The quality of the plants and flowers were equally high on the conventional and biological/systemic chemical treated plants.

Credits

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Nancy Rechigl, USRS, Syngenta Company.

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WOODY ORNAMENTALS FOR THE FLORIST TRADE

Christopher Uhland, Harmony Hill Nursery LLC
2022 Mid-Atlantic Fruit & Vegetable Convention
Hershey Lodge, Hershey, PA
February 3, 2022, 10:15-11:00AM

Harmony Hill Nursery, LLC started as a Production Nursery for the Landscape trade. Entire farm is preserved under an agriculture easement through Chester County. The production acreage is enclosed by a 10' tall wire deer fence in Downingtown, PA, can grow anything without the deer pressure.

HHN stumbled upon the Cut Stem industry during the 2009-2013 Economic Downturn through my wife, manager at a Floral Design firm in Philadelphia that offered to take some material we were long on instead of destroying everything. Realized we can sell this instead of destroy excess

Have researched cut stem production through the nursery network, toured the largest Winterberry grower in the US, 90 acres of solid Winterberry. Toured several other smaller growers, other growers that supplemented their business with cut stems

Key is to specialize or have a pallet of material that you can specialize in with either high quality (good volume but high quality to cater to discerning designers) or large volume (cheap wholesale price to brokers).

Planting methods: unrooted cuttings, roots cuttings, plugs, containers, bare root. Spacing and layout for your production & harvesting methods. Discover space that conventional ag can't use- wetlands, irrigation runoff, woodlands, buffer zones, hedgerows, stormwater swales, etc

Cultivar selections: what do you want to offer & what do your clients want? Old stand byes or new cultivars, Proven Winner, Plant Nouveau, UpShoot!, European breeders, foraging what nature offers- the pros & cons. What does "Martha" suggest? Lots of trialing, talking to designers or brokers.

Production Methods: organic, conventional, weed control is a must for reduced competition. Fertilizer application at optimal times. Mycorrhizae & compost for optimal soil health. Leaf compost, mulch or wood chips for weed suppression, u-pick it, eye appeal.

How to harvest; coppice vs pollard pruning, annual, biannual, tri-annual harvest, full length stem or specific lengths. Loose branches, boxed branches, tied/banded bundles, sleeved.

How to sell, direct to retail, wholesale, coops. Easily sold online and shipped via USPS, FedEx, UPS, common carrier. Antique/vintage shops! Social Media LOVES fields of cut stems- winterberry, Lilac, hydrangea, big color- make money from photographers. Do not undersell locally grown material. Most material florists use comes from out of the area, sits in a cooler, isn't fresh, you can cater to their specific needs- local growers. Several ways to generate revenue from cut stems!

WEED MANAGEMENT OPTIONS FOR FIELD-GROWN CUTFLOWERS.

Andrew Senesac, Cornell Univ Extension

The first opportunity for weed management often occurs the season before the crop is planted. It is possible to avoid planting on land that is seriously infested with difficult-to-control weeds if the grower knows what to look for. Creeping perennial weeds such as yellow nutsedge, mugwort and hedge bindweed are very difficult to control once a flower crop is planted. If it is not possible to avoid such a site, then it is important to manage these weeds the season before planting. Repeated applications of a non-residual postemergence herbicide and/or repeated disking or harrowing will usually be very effective in bringing the perennial weed populations down to a more manageable level.

Sometimes chemical soil fumigation in the fall or spring prior to planting is one option that some growers consider. Fumigation should be considered if there are other serious soil soil-borne pests that can only be controlled in this manner or if no other chemical means of weed control are being considered. Fumigation is expensive and, while effective in controlling seed-propagated weed species, it is often poor in controlling creeping perennial weeds.

Pre-emergence herbicides are sometimes applied pre-plant, but usually applied post-plant or post-transplant and always preemergent to the weed. They are generally active on germinating weeds and usually need either incorporation by cultivation or water (irrigation or rain) to activate and move the chemical into the zone in the soil where the weed seeds are germinating. Some can be applied prior to transplanting, although usually cutflower safety is enhanced by having the transplant roots well below the herbicide layer. A few cutflower species are direct seeded. The larger seeded species such as zinnia and sunflower can usually tolerate registered herbicides. However, most of the smaller seeded cutflower species are very susceptible to injury if they are direct seeded and then immediately exposed to a preemergence herbicide. It is always essential to read the label before buying or applying any herbicide to be sure that the crop and weed are listed, as well as for information on proper dosage and timing. When considering the possibility of using a pre-emergent herbicide, in general, safety to the flower crop increases with:

- Larger transplants
- Applying the lowest labeled rate
- Delayed application after planting for better root establishment
- Granular formulations if a choice exists versus a spray
- Directed sprays to the base of the plants-not spraying the entire plant

Some post emergence herbicides are very selective in controlling only the grassy weeds that have emerged. Sethoxydim (Segment, Poast), and clethodim (Envoy & others) have now been labeled for over-top application in several cutflower species. Injury symptoms on the weeds usually take 7-10 days to be visible and they are effective in controlling grasses only (not sedges or broadleaves) but can be a valuable rescue tool if grassy weeds are a problem. For more information about which herbicides to use, consult the Cornell Pest Management Guidelines for Greenhouse Crops and Perennials. https://cropandpestguides.cce.cornell.edu/Guidelines/GCHO

Another important component of an effective weed control strategy consists of nonchemical methods and practices which, either alone or in combination with herbicides, can help prevent weed infestations from becoming economically damaging. Among these are proper fertility and placement, irrigation, and pH management and selection of cutflower species or cultivars which are well adapted to the site. Weeds are great opportunists and will take advantage of any condition which tends to stress the crop. Mulches, either organic or plastic, can be a very effective and practical means of controlling weeds, particularly with transplants in a multi-crop, low acreage operation. Controlling harmful insects and diseases allows the crop to be a better competitor. Hand weeding or rogueing escaped weeds before they disperse their seed will help alleviate next year's problem. Narrower in-row and between-row spacing allows the crop to cover the bare ground more quickly, thus shading out the weeds more effectively.

In summary, it is important that the grower develops a rational strategy well before the start of the growing season using all or some of these tools to economically manage weeds.

Andy Senesac, Ph.D., Cornell University Cooperative Extension of Suffolk Co., Long Island Horticultural Research and Extension Center. 3059 Sound Avenue, Riverhead, NY 11901

SOIL STEAMING IN HIGH TUNNELS

Becky Maden
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In recent years, chickweed has become a widespread problem in high tunnel winter greens production in Vermont and the Northeast. Left uncontrolled, chickweed has been observed to lead to up to 100% crop losses of winter greens in infested high tunnels. Most growers who have chickweed in their tunnels control it through manual removal, which is slow, costly, and must be repeated as seed germinates. Both organic and conventional farms rely on physical controls since few herbicides are labeled for use in high tunnels. To manually control chickweed in a typical 30'x96' house with moderate infestation requires an estimated 30 person hours annually (3 weeding dates, 10 hours each, at $15/ hour) for a total cost of $450 per house, per year. Even with such aggressive manual weed control, growers report that their average yield reduction due to competition from chickweed is still about 50%, which is lost revenue of $4,320 annually, assuming a potential yield of 1 lb./ft2 and a market price of $3/lb.

Chickweed is well adapted to growing in high tunnels over winter. It emerges primarily in the fall, with optimal germination temperatures of 53 to 68 degrees F. It can flower within a month and set seed in 2 to 3 months, producing an average of 25,000 seed per plant. This weed thrives in high fertility, moist soils. It is an excellent nitrogen scavenger. It can take 3 years for the seed bank to be reduced by 50% and up to 6% of seeds may remain viable after 10 years (Michigan State University).

An alternative chickweed management strategy is soil steaming. This technique has long been used in floriculture greenhouses, tobacco fields and other commodities, for controlling weeds and soil borne disease. Our project uses the steaming system currently adopted by a handful of Northeast growers, which deploys a portable boiler to generate steam that is applied through tubes placed under a heavy tarp covering the soil surface, raising the temperature in the top few inches of soil up to 83°C (180°F). This temperature has been observed to be high enough to reduce chickweed populations for up to three years.

Though soil steaming is used worldwide, in part as an alternative to fumigating with materials such as methyl bromide, little is known about its effect on soil biology. Most high tunnel growers in the Northeast try to use practices that promote healthy soil biology, so they have reasonable concerns about the effect of high temperatures during steaming. The lethal temperature for different soil organisms has been well documented, and it is known that most weeds are killed at lower temperatures than soil microorganisms (Fennimore, et al). This project documents the impact of different soil temperatures on microbial populations by collecting soil samples at different times in the winter growing season and analyzing them for biological activity. This will inform the optimal steaming duration in high tunnel systems needed to control chickweed while supporting microbial communities in the soil.

Previous research has demonstrated that high steam temperatures can seriously impact nutrient cycling and availability, especially in soils with high levels of organic matter (as is common in high tunnels). Once the soil reaches 180° F, bacteria that convert organic matter to nitrate are killed, whereas the bacteria that convert organic matter to ammonia may survive. This can lead to a high ammonia content in the soil several weeks after steaming. It is likely that growers would not wish to plant crops into the high tunnel during this high ammonia period, to avoid root burning and crop losses. Over-steaming is also shown to cause a build of other toxic substances in the soil, in

Becky Maden works with vegetable farmers through University of Vermont Extension. Her primary focus is on soil health practices and high tunnel growing, using a farmer led participatory action research approach to inform her work. Prior to her work with Extension, she farmed commercially for 15 years, and currently operates an organic vegetable operation with her family in Orwell, Vermont.

particular manganese and soluble salts (Fennimore et al., 2014).

This on-farm research project is generating data to identify best practices for soil steaming to control chickweed and support healthy soil. During the fall/winter of 2020 and 2021, we rented a soil steamer and applied three different steaming temperatures in replicated blocks. We are assessing the percent of chickweed mortality over the course of the two-year study. Soil samples are taken using normal sampling procedures (6-inch depth, aggregating 15 sub-samples per plot) and analyzed using the saturated media extract method to measure soluble nutrient levels, including soil nitrate and ammonium, as well as pH and total soluble salts.

To sample for microbial activity, we are using the Biolog Ecolog plate, which is a technique that characterizes carbon and nitrogen substrate utilization as in indicator of microbial populations. We are comparing treatments before steaming, one week after steaming, one month after steaming, and six months after in each year of this project to track changes in microbial activity.

Although we are just over half way through this study, some preliminary conclusions include:

- Steaming can increase net revenue by reducing yield losses to chickweed
- Chickweed control is not long term when there is a high weed seed bank
- Steaming appears to reduce damping off in spinach
- Microbial activity and diversity appear to rebound within a year after steaming
- Crop growth appears enhanced after steaming, nitrate availability
- It can be challenging to achieve/maintain optimal soil temperatures with steaming
- New steamers ($$$) are much easier to maintain and use than used steamers ($), but basic functions are equal

APHID CONTROL FOR HIGH TUNNELS DURING COLD TEMPERATURES

Laura L. Ingwell
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We are talking about high tunnel production systems today because this method of growing under protection adds value to any farm by extending the season and providing high quality crops. Additionally, they are very affordable and accessible to farmers of all sizes and locations. As well as providing protection to your crop, they also protect the pests that colonize your crops. My previous work has shown that in addition to combating the traditional soft-bodied pests that are common in protected culture (aphid, thrips, mites, whiteflies) there is increased pressure from caterpillar and beetle pests in high tunnels. We have done extensive research to identify the most productive crops in high tunnel systems, depending on the season and market. What is less understood is how pest dynamics (insects and pathogens) vary across the seasons and with the cropping systems. The focus of this presentation will be a review of the aphid lifecycle, in general, and how/when they pose a threat during cold season production. Natural enemy and organic pesticide considerations will be discussed in relation to the impacts of temperature, relative humidity, and day length.

Aphids are piercing-sucking insects belonging to the Order Hemiptera (true bugs). They can vary in size, shape, color, and the part of the plant on which they feed. There are some aphid species that specialize on the root zone and feed at the plant-soil interface. The most common types of aphids that are encountered in high tunnels are foliage-feeding aphids. Species include the green peach aphid (Myzus persicae), the melon aphid (Aphis gossypii), tomato/potato aphids (Macrosiphum euphorbiae), cabbage aphids (Brevicoryne brassicae) and a host of others that may be less common.

The majority of the year aphids are present on the landscape as asexual reproductive females. This means that the population is all female and they produce offspring clonally. Aphids undergo incomplete metamorphosis; the offspring look like smaller versions of the adults. There are two body types, those with wings and those without. Their color can vary, but these are the same insect! Winged individuals are produced when the quality of the host plant declines, the population becomes overcrowded, or they are looking for a new host.

Some species of aphids switch to a sexual reproductive form and over winter on an alternate host. This include the bird cherry-oat aphid. The summer, asexual populations feeds on grass hosts (such as oats, wheat, and corn) and switches to a sexual form (male and female), migrating to cherry trees in the winter. On this new host they will mate, lay eggs and the eggs will overwinter. See below an example of this lifecycle, taken from Aphids, High Tunnel Pest Management by Nick Volesky and Zachary Shumm. In high tunnels, we do now know if aphids overwinter as asexual individuals, continually feeding, or as overwintering eggs from sexual reproduction. There is evidence to support both of these life histories.

Dr. Laura L. Ingwell is an Assistant Professor in the Department of Entomology at Purdue University. Her primary role is an Extension Specialist of Pest Management in Horticultural Crops. Dr. Ingwell's research focuses on pest management on specialty crops grown in protected environments. In particular, she is interested in evaluating the role of natural enemies and biopesticides, developing new strategies to increase their ability to suppress pest populations. Dr. Ingwell works in Urban Agricultural systems as well, strengthening our knowledge and tools to manage insect pests and produce organic soil amendments through the application of black soldier fly composting. Dr. Ingwell is responsible for sweet corn pest management programs in the state of Indiana. She earned her M.S. from the University of Rhode Island in 2009 and a Ph.D. from the University of Idaho in 2014. She originally hails from Wisconsin, where her roots in agriculture were established.

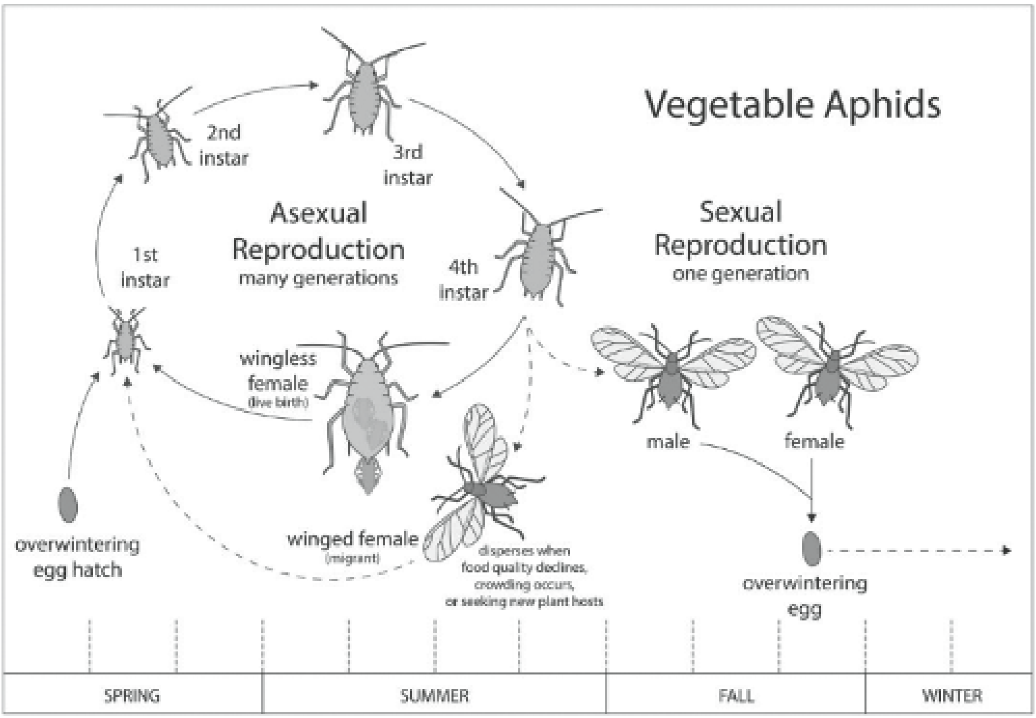

Fig. 6 by Cami Cannon reprinted from Aphids, High Tunnel Pest Management by Nick Volesky and Zachary Schumm, Utah State University Pest Fact Sheet, March 2021.

Drawing from our IPM toolbox, we have a variety of tools and techniques that we can apply to aphid management during cold temperatures.

1. Prevention is still the most important tool. Minimize reservoirs and secondary hosts through weed management and reducing overlapping crops. Continue to inspect transplants and use order of entry protocols to work in an infested area only after you have completed work in the clean area.

2. Monitor often to detect early infestations. Scout the plants early (as soon as they germinate or are transplanted) and often (at least once per week). Install passive monitoring tools, such as sticky cards, to help!

3. Know your natural enemies. Who colonizes on their own and who can you supplement by purchasing from commercial suppliers. Under cold temperatures many of these natural enemies enter a state of rest to survive the winter. They may be feeding less often or not at all, and therefore you may have to rely on organic and biological pesticides for control. If you choose to purchase natural enemies from a commercial supplier, be sure you know the environmental conditions in the HT to be sure the temperature can support predator foraging. Preliminary work done by Anna Wallingford at the University of New Hampshire has shown that lacewing larvae can be effective at suppressing aphid populations when temperatures are in the range of 28.75-100.95 °F during a 7-day observation period.

4. Pesticides may be needed to maintain control. There are a variety of organic options available. Some of these are biological pesticides (i.e. living organisms that can kill insects). They, too, are most effective under optimal environmental conditions and applications. Be sure to check the labels closely to maximize each and every application you choose to make.

Active Ingredient	Product	Efficacy*	Environmental Considerations
Azadirachtin	Neemix® 4.5	G,F	Longer duration of leaf wetness increases effectiveness
Azadirachtin, pyrethrum	Azera®	G,F	Not explicit, early morning and evening applications increase performance (reduced UV exposure and lower temp)
Beauveria bassiana (fungus)	BioCeres® WP	variable	UV sensitive, humidity ≥ 60%, temp 64-84°F
Burkholderia spp. (bacteria)	Venerate® XC	G	none
Chromobacterium subtsugae (bacteria)	Grandevo® CG	P	none
oils	SuffOil-X®, Ecotec®	G,F	Do not apply >90°F
Potassium salts of fatty acids (soap)	M-Pede®	variable	Potential for injury when plants are stressed (heat, humid, drought)
pyrethrins	Pyganic® 1.4 EC	G	Degrade rapidly in sunlight

* G = good, F = fair, P = poor

Regardless of the product, apply when populations are low, target young individuals, get good coverage of the infested plant parts.

5. Evaluate whatever control methods you employ. Monitor the retention of predators. Record how quickly you see reductions in pest populations. Monitor which stage of the insect is controlled and for how long. Your IPM program should be constantly evolving and in order for that to happen, you need to track what works and what doesn't.

ANAEROBIC SOIL DISINFESTATION (ASD) FOR ORGANIC HIGH TUNNELS

Francesco Di Gioia - Department of Plant Science, Pennsylvania State University

Soil health is defined as "the capacity of a soil to function as a vital living system and sustain plant and animal productivity, maintaining or enhancing water and air quality, and promoting plant and animal health" (Doran and Zeiss, 2000). Maintaining and enhancing soil health is therefore a key priority in organic agriculture. Organic farmers invest on the health of their soil by implementing a series of management practices such as the application of organic amendments, crop rotations, the use of cover crops, and other soil management practices that have a beneficial effect on soil health. One critical goal of such management practices is to maintain or generate soils that are suppressive of soilborne pests and pathogens. Nevertheless, despite the efforts made to enhance soil health, organic crops can still be subject to soilborne pests and pathogens, especially when soil is grown intensively, like in the case of specialty crop protected cultivation systems such as high tunnels. Specialty crop organic growers are constantly striving to find effective and viable biological approaches to manage soilborne issues.

Anaerobic soil disinfestation (ASD) also known as biological soil disinfestation (BSD) is a pre-planting microbial-driven biotechnology increasingly proposed to manage a range of soilborne pests and pathogens including fungal and bacterial pathogens, plant-parasitic nematodes, and weeds. The method originally developed in Japan and The Netherlands, integrates in principle primitive soil management practices such as the amendment of the soil with organic matter, soil flooding, and soil solarization. Anaerobic soil disinfestation is implemented amending the soil with organic amendments that can provide a readily decomposable source of carbon (in principle similar to soil organic amendment), tarping the soil with a clear or opaque impermeable film that has the function of limiting gas exchanges (in principle similar to soil solarization), and saturating the soil with water to enhance the development of anaerobic conditions (in principle similar to soil flooding).

The amendment of the soil with a labile source of carbon, stimulates a rapid microbial growth, which combined with the water saturation and the use of an impermeable film, rapidly leads to the development of anaerobic conditions. Under anaerobic conditions facultative and obligate anaerobe microorganisms continue decomposing the source of labile carbon through a sort of fermentation process that leads to the production of organic acids and volatile fatty acids that combined with other processes contribute to suppress soilborne pests and pathogens.

The ASD treatment is generally applied 3-4 weeks before planting the crop, and should be applied when soil temperatures are above 60 F. In fact, being ASD a microbial-driven process it benefits from relatively higher temperatures, but compared to soil solarization, the ASD process does not rely on the development of very high soil temperatures, and therefore it can be applied even in regions that are not characterized by high solar radiation levels like the Mid-Atlantic region. Nevertheless, previous studies suggest that higher temperatures promote faster microbial growth and the development of anaerobic conditions determining a higher efficacy in suppressing soilborne pests and pathogens.

Irrigation of the soil to field capacity enhances the development of anaerobic conditions, but ASD does not require the soil to be flooded for long periods and is therefore much more sustainable and easier to apply than soil flooding which is applicable only in certain regions.

Previous studies suggest that compared to other soil disinfestation approaches that are based mainly on physical principles (soil solarization, soil steaming), ASD is a microbial-driven process that allows to selectively manage soilborne pests and pathogens, while promoting the growth of beneficial microorganism which may contribute to the suppression of soilborne pests and pathogens beyond the soil treatment period.

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.

Timing of the ASD application and the selection of locally available sources of labile carbon are two key aspects that can determine the efficacy and economic viability of the ASD method, and a multidisciplinary research and extension effort is required to integrate and optimize the ASD method in organic high tunnel production systems commonly used in the Mid-Atlantic region. Current research is aimed at evaluating the use of cover crops and locally available organic amendments as sources of carbon, while examining the efficacy in generating anaerobic conditions and suppressing soilborne pests and pathogens and evaluating the impact on nutrient dynamics and overall soil health.

Optimizing the ASD method for organic specialty crop high tunnel production systems commonly used in the Mid-Atlantic region may provide organic farmers with a new solution that integrated with other strategies can contribute to generate healthy soils, suppressive of soilborne pests and pathogens. Anaerobic soil disinfestation may be used not only to address specific soilborne pest and pathogen issues but could also facilitate the transition from conventional to organic production practices.

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IMPACT OF MANAGEMENT PRACTICES AND CROPPING SYSTEMS ON STORED WINTER SQUASH NUTRIENT QUALITY

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Butternut winter squash (*Cucurbita moschata* Duch.) 'Waltham' is known for being a good source of minerals such as potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), iron (Fe), and selenium (Se), vitamins (C, E, K, B1, B2, and B6), dietary fiber, and phenolic compounds. Winter squash is valued for its orange flesh color, which is related to total carotenoid content, an important phytonutrient.

t squash is widely grown in conventional and organic cropping systems in the United States. Specialty crop growers use intensive tillage to prepare winter squash beds prior to transplanting seedlings into either bare beds or covered with black plastic mulch. Repeated intensive tillage over time, as well as seasonal cultivations to control weeds during the growing season, may lead to a reduction in soil health.

Soil conserving tillage practices known as reduced- or no-till agriculture could reduce degradation and improve soil health. While conventional growers use herbicides to burn down cover crops prior to transplanting winter squash seedlings or between plastic beds, organic growers depend on either mowing or roll-crimping the cover crop to serve as residue mulch and control weeds. These practices and cropping systems play major role in degrading or building soil health and availability of nutrients for plant growth and accumulation in harvested crop. Winter squash fruits store well and can provide food for several months during the fall and winter. When properly cured and stored, the winter squash may last up to three months.

Results from research studies conducted on pumpkin and winter squash showed that long-term storage of pumpkins resulted in the accumulation of phytonutrients such as lutein, carotene. Other studies showed increase in sugar content in stored winter squash and sweet potato. However, there is little information on the impact of management practices and cropping systems on post-harvest winter squash nutrient quality with long-term storage period.

A two-year research project was established in the long-term Vegetable Systems Trial at Rodale Institute in 2020 to gather scientific information to deepen our knowledge on how management practices and cropping systems impact mineral and phytonutrient quality of winter squash when stored for a long period.

In a randomized block design with two cropping systems (organic and conventional) with four replications, two management practices were applied: 1) intensive tillage using moldboard plow to plow under the cover crop and covering beds with black plastic mulch (referred to as BP) and 2) reduced tillage where cover crop was either burnt down with herbicide in spring prior to transplanting as practiced by the conventional growers or roll-crimped with a 10-ft roller-crimper to form mulch and control weeds (referred to as RT). Winter squash were transplanted 60 cm (2-ft) apart in rows. Plants were monitored for pest and disease pressure. Harvested winter squash were cured for two weeks and stored in a dark and cool room at 0, 30, 60, and 90 days. At the end of each storage period winter squash fruits were weighed and processed in the laboratory by peeling and cutting the squash into 1-inch cubes, stored in a freezer at -20 C. The freeze-dried and ground samples were then sent to Penn State University AASL for

Dr. Gladis Zinati, Director of the Vegetable Systems Trial at Rodale Institute, is a Soil Scientist and Horticulturist with 30 years of experience in soil and crop management. Her research focuses on linking soil health to crop and human health by evaluating the impact of cropping systems and management practices on nutrient cycling, carbon sequestration, and vegetable nutrient density. Dr. Zinati earned her Ph.D. in Soil Fertility-Soil Science from Michigan State University; a M.S. in Horticulture from the American University of Beirut; a B.S. in General Agriculture and Agriculture Engineering from the American University of Beirut.

mineral nutrient analysis. Total phenolics, sugars, and carotenoids (lutein and alfa carotene) were measured at Dr. Reddivari's laboratory at Purdue University, and total proteins at the Experiment Station Chemical Laboratories (ESCL) at the University of Missouri.

In this article, we are reporting on concentrations of minerals and phytonutrients including proteins, lutein, alfa carotene, and phenolics from 2020 stored winter squash.

Mineral Nutrients:
Our data showed that percent mineral nitrogen (N), P, and sulfur (S) were significantly greater in organic winter squash (averaging 1.1%, 0.44% and 0.16%, respectively) when compared to conventional (averaging 0.86%, 0.39% 0.14%, respectively). However, there was no significant difference in K, Ca, and Mg levels between cropping systems. Levels of N, P and S in winter squash did not vary with the storage period.

Reduced-tillage practices enhanced P, K, and Ca levels in 0-day stored winter squash when compared to those in intensively tilled plots with plastic mulch. However, the latter practice increased N levels in winter squash when compared to those in reduced till. As storage period increased from 0-day to 90-day, N levels increased in BP winter squash from 1.0% to 1.10% whereas no significant increases were found in RT squash. Potassium levels continued to increase up to 60-day of storage and declined by 90-day in both BP and RT winter squash.

Total Proteins:
Organic winter squash contained a greater protein level (7.37%) and was significantly greater when compared to conventional winter squash (5.89%). Protein level increased steadily with storage period. Like N, protein % was greater in BP than in RT winter squash.

Total Phenolics:
Total phenolics was greater in organic winter squash averaging 247 mg/100g dry weight compared to conventional, averaging 221 mg/100g dry weight. The management practices did not impact the total phenolics in winter squash. However, total phenolics declined with the storage period.

Carotenoids:
Carotenoid lutein level almost doubled in winter squash averaging 227 microgram equivalent/g dry weight at 90-day storage compared to 0-day storage (averaging 127microgram equivalent/g dry weight). Similarly, alfa carotene increased 2.5 times in 90-day stored squash when compared to those without storage.

Total sugars:
Winter squash total sugars increased with storage period from 266 mg/g dry weight at 0-day to 490 mg/g dry weight at 90-day.

S, lutein, alfa carotene and total sugars were significantly greater in conventional winter squash than in organic, whereas levels of N, P, S, and total phenolics were significantly greater in organic winter squash compared to conventional. Management practices did not impact total phenolics, lutein and total sugars, but alfa carotene, P, K, and Ca were greater in reduced tillage than in tilled with plastic mulch treatment. Nitrogen levels increased in BP winter squash as storage period increased, whereas, K continued to increase independently of management practice. Hence, increasing the storage period will enhance the nutritive quality of winter squash and consequently their consumption will aid in added health benefits.

ASSESSMENT OF SOIL HEALTH INDICATORS IN THE VEGETABLE SYSTEMS TRIAL AT RODALE INSTITUTE

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Soil and crop management decisions, including crop rotation, residue management, and intensity and frequency of tillage, affect soil health and soil nutrient dynamics. Repetitive and intensive tillage can degrade soil health by mechanically reducing soil aggregates and oxidation of soil organic carbon (SOC) upon decomposition by soil microbes.

Research studies have shown implementing conservation tillage (including no –tillage, NT, and reduced tillage, RT) with or without crop residue retention can potentially increase SOC, improve soil structural stability, soil nutrient availability, and water holding capacity, which eventually lead to greater crop productivity and SOC sequestration.

There is a plethora of published research studies on soil health indicators in long-term agronomic ecosystems, suggesting that SOC and labile or active fraction of soil organic matter, known as POX-C are used as sensitive indicators of management effects on soil health. The presence of organic carbon in soil is a key determinate of soil productivity and a key influencer on physical, chemical, and biological properties. The SOC exhibits the long-term balance between additions of organic carbon from various sources and its losses through different pathways. Short and medium-term SOC changes in response to management practices are difficult to detect, however, the more labile (active) constituent of SOC fractions can be a useful parameter of soil health and a sensitive indictor of the impact of cropping systems and management practices. However, there is a need to identifying soil health indicators where annual vegetable crops grown in long-term trials.

The Vegetable Systems Trial (VST), a long-term trial at Rodale Institute is well set up to assess soil health indicators in soils that were subjected to various cropping systems and management practices as in the case of winter squash.

Background on management practices and cropping systems in the VST:
In the VST, the winter squash is grown annually into two cropping systems (conventional (CNV), and organic (ORG)) with two management practices [intensive tillage with black plastic mulch (BP)] and reduced tillage (RT) in a randomized block design with four replications. The ORG system includes cover crops (hairy vetch with cereal rye; HV/R), organic amendments, and management of pests organically when needed. The CNV system, on the other hand, includes cereal rye (R) as a cover crop and uses conventional herbicides (e.g. glyphosate) to burn down the cover crop and weeds in the spring, as well as synthetic fertilizers and pesticides. In both systems, the BP practice includes plowing under the cover crop using a moldboard plow, disking, and packing before forming beds covered with plastic mulch and transplanting winter squash. Seasonal cultivation is used between beds to control weeds in the ORG system, whereas, in the CNV system the weeds are controlled by spraying glyphosate herbicide between squash plastic beds. The cover crops in the RT plots, on the other hand, are either roll-crimped as in ORG system or burnt down with glyphosate without roll-crimping as in CNV before transplanting winter squash seedlings. After harvest in the fall, the beds are prepared with cover crops for the next season.

Dr. Gladis Zinati, Director of the Vegetable Systems Trial at Rodale Institute, is a Soil Scientist and Horticulturist with 30 years of experience in soil and crop management. Her research focuses on linking soil health to crop and human health by evaluating the impact of cropping systems and management practices on nutrient cycling, carbon sequestration, and vegetable nutrient density. Dr. Zinati earned her Ph.D. in Soil Fertility-Soil Science from Michigan State University; a M.S. in Horticulture from the American University of Beirut; a B.S. in General Agriculture and Agriculture Engineering from the American University of Beirut.

Soil Sampling

In fall 2020, two soil cores per winter squash plot were collected from 0-30cm depth and transported to the lab. Each core was sectioned into three sections with 10 cm increment. A composite soil sample was established per each section, mixed thoroughly in a plastic bag, and processed before shipping out to various laboratories for assessment of soil health indicators: SOC, POX-C and soil microbial biomass.

Processing soil samples

Each composite soil was subdivided into two subsamples. One subsample was air-dried, sifted through 2-mm sieve, and sent out to Soil Fertility Laboratory at Ohio State University for determining SOC and POX-C levels. The second subsample was stored immediately in a freezer at -10 C before sending it out to Ward Laboratory for determining soil microbial biomass using the phospholipid fatty acid (PLFA) method.

Results

Soil organic carbon

Percent soil organic carbon was slightly greater in the ORG system (averaging 2.28%) when compared to that of the CNV (averaging 1.98%), however, these values were not statistically different. The SOC percent was greater in the RT plots at 0-10 and 10-20 cm soil depths when compared to those in BP. The SOC percentage was about 70% lower at 20-30 than in the 0-20 cm depth, as shown in Figure 1.

Soil labile organic carbon (POX-C)

When the data from 0-20 cm soil depth were pooled, the POX-C levels were significantly greater in the ORG cropping system than those in the CNV (Figure 2). Although the POX-C levels were greater in the RT plots than in BP plots, these values were not statistically different in the 0-20 cm soil depth. However, POX-C levels varied with soil depth and was greatest in 0-10 cm and lowest in 20-30 cm (Figure 3).

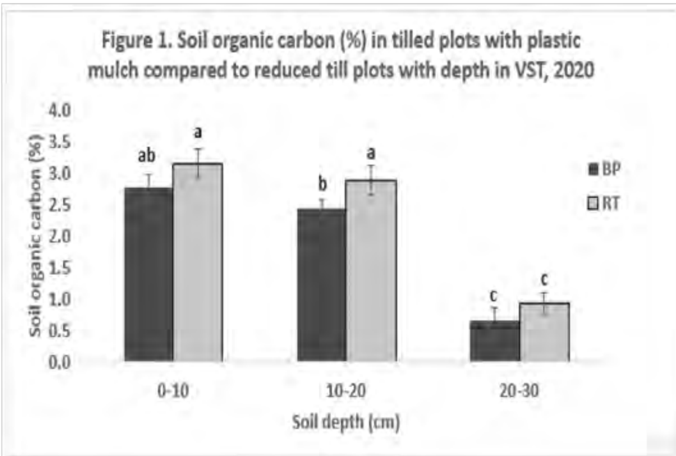
Soil microbial biomass

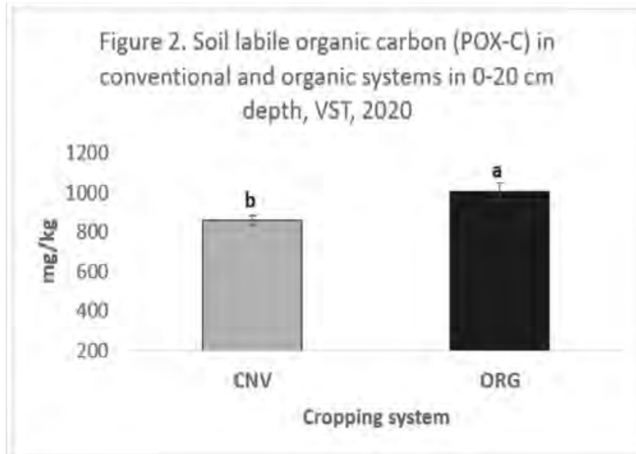
Bacterial biomass was greater in the CNV system than in ORG but was not statistically different (averaging 817 ng/g soil). Fungal biomass was greater in CNV (averaging 116 ng/g soil) compared to organic (averaging 59 ng/g soil). Soils managed with RT practices had significantly greater bacterial biomass (averaging 1035 ng/g soil) than the BP (averaging 600 ng/g soil). However, soil fungal biomass (averaging 84 ng/g soil) did not vary with management practices. Bacterial biomass varied with soil depth and was significantly greater in the top 10 cm, averaging 1285 ng/g soil, than in the lower soil depths, 10- 20 cm and 20-30 cm, (averaging 862 ng/g soil and 300 ng/g soil, respectively). The fungal biomass followed the same trend as bacterial biomass, where the top layer contained 144 ng/g soil on average, lowest in the 20-30 cm (averaging 35 ng/g soil) and moderate (averaging 84 ng/g soil) in the 10-20 cm depth.

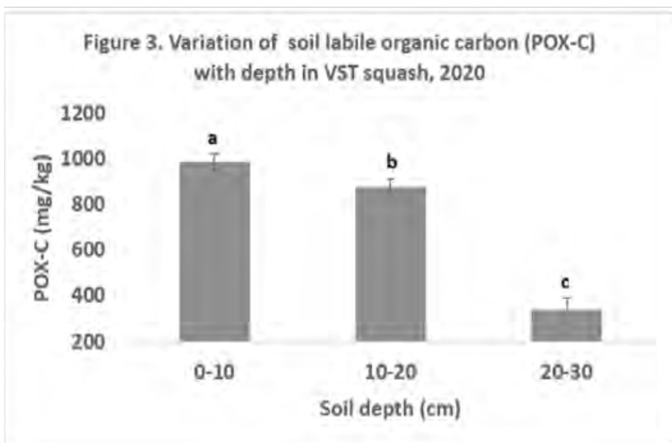
In short, the results presented here from this trial showed:

- The SOC percent did not vary with cropping systems, however, implementing reduced tillage increased SOC percent when compared to BP. These values were greater in the to 20 cm.
- The POX-C soil health indicator was a more sensitive than the SOC to cropping systems and soil depth than to management practices. Soils with POX-C values between 600 to 1000 mg/kg are considered healthy. Such values were evident in the top 20cm soil depth where soil microbial organisms have access to carbon sources as food more than at the deeper soil layer where SOC percent was low.
- Fungal biomass varied with cropping systems whereas bacterial biomass varied with management practices. Both soil bacterial and fungal biomass varied with soil depth.

In conclusion, management practices and cropping systems can influence the buildup of SOC and POXC as well as soil microbial biomass. Further research is needed over multiple years to show the long-term effects on soil health indicators in vegetable cropping.







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DEALING WITH BROAD MITES IN ORGANIC PRODUCTION SYSTEMS

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Broad mite, *Polyphagotarsonemus latus*, is a tarsonemid mite closely related to and similar in appearance to the cyclamen mite, *Phytonemus pallidus*. Broad mites feed on plants in over 60 plant families including a wide variety of ornamentals and vegetables; such as, begonia, chrysanthemum, cucumber, dahlia, eggplant, impatiens, pepper, strawberry, tomato, and zinnia.

BIOLOGY

Adult broad mites are about 0.25 mm (0.0098 of an inch) long, shiny, amber to dark-green, and oval-shaped. There are four life stages: egg, larva, nymph, and adult. Females lay up to 40 eggs during their two-week lifespan, although the number of eggs laid depends on temperature and relative humidity. Eggs are laid on the underside of plant leaves. Eggs are oval, white, and covered with bumps or protrusions. Larvae emerge (eclose) from eggs, transition into nymphs, and then become adults. Development from egg to adult takes five to six days at 21 to 26°C (70 to 80°F) and seven to 10 days at 10 to 18°C (50 to 65°F).

Broad mites infest plants when temperatures are between 15 and 21°C (60 to 70°F) and the relative humidity is 60 to 80% because these environmental conditions are conducive for development and reproduction. All life stages (egg, larva, nymph, and adult) may be present simultaneously during the growing season. Broad mite populations can spread among crops by means of air currents (wind) or when the leaves of adjacent plants are touching.

DAMAGE

Broad mites tend to congregate and feed in groups on the underside of young leaves and in flower parts, including flower buds, which inhibits plant growth and prevents flowers from fully developing. Broad mites feed on plant cells within the leaf epidermis using their piercing-sucking mouthparts. While feeding, broad mites inject a toxic salvia that causes twisted, hardened, and distorted terminal plant growth. Additional symptoms include: leaf bronzing, leaf margins curling downward and becoming brittle, and puckered and shriveled growth. Extensive populations of broad mites on plants will lead to individuals migrating and feeding on the upper leaf surface, which can result in severe leaf distortion.

Broad mite feeding damages the meristematic plant tissues associated with the growing tip or apical shoot, which inhibits growth, decreases leaf number, leaf size and area, and reduces plant height. In addition, leaves may appear "roughened" and darker green than normal. Broad mite damage resembles nutritional deficiencies, herbicide damage, watering problems, or improper environmental conditions (e.g. temperature). In most cases, broad mites are considered the culprit after plant damage is noticeable because broad mites are difficult to see with the naked eye. A dissecting microscope can be purchased, which will help to see broad mites on plant parts.

MANAGEMENT

Broad mite management in organic production systems involves disposing of all plants exhibiting symptoms of broad mite feeding damage. In addition to discarding plants exhibiting damage symptoms, remove plants adjacent to symptomatic plants, even if they are not showing symptoms, because the plants are likely infested with broad mites. There are very few pesticides registered for use against broad mites in organic production systems. Sulfur and

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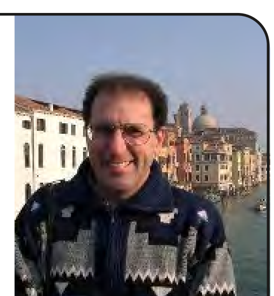

mineral or neem-based oils may be options. However, these are contact pesticides so thorough coverage of all plant parts and repeat applications are required. Also, read the label directions to determine if crops are susceptible to damage from pesticide applications.

Biological control of broad mite entails releasing the predatory mites: Neoseiulus cucumeris or N. californicus. Release predatory mites early in the crop production cycle before broad mite populations are established and causing plant damage. Predatory mites can be released among a crop using either sachets or containers. Consult a biological control supplier or distributor to determine appropriate release rates.

For more information on broad mite, refer to the following extension publication:

Cloyd, R. A. 2010. Broad mite and cyclamen mite: management in greenhouses and nurseries. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2938. Kansas State University, Manhattan, KS. 4 pages (https://www.bookstore.ksre.ksu.edu/pubs/MF2938.pdf)

DEPLOYING ECOLOGICAL PEST MANAGEMENT TACTICS TO MANAGE PESTS IN ORGANIC VEGETABLES

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Conventional vegetable producers often rely on synthetically derived products as a crutch to keep insect herbivores and other agricultural pests in check. In addition to their potential to cause harm to the environment as well as beneficial organisms above and below the soil, using synthetic pesticides is not an option for organic farmers. In light of a reduced availability of products, lower efficacy issues and greater price tag for some organically approved pesticides, organic farmers are challenged with identifying alternative pest management options that meet organic farming standards. These challenges are accentuated because yields of organic crops are roughly 80% of their conventional counterparts. Still, there are opportunities to develop low cost, efficacious management practices that address organically grown crops' vulnerability to pests and yield reductions. One option involves using the ecological pest management (EPM) concept. Similar to cultural control, this approach focuses heavily on preventive rather than reactive measures. The EPM approach relies on ecological principals and our knowledge of pests and their interactions with crops and other organisms to manage them. This strategy can be considered a component of integrated pest management (IPM), as the goal of IPM is to use multiple management tools in a mutually supportive manner and apply ecological principles to manage pests.

The central theme of EPM is to 1) thoroughly understand a pest's ecology in relation to its host plant and environment, 2) learn the weak links in a pest's seasonal life cycle and 3) modify husbandry practices to exploit those weak links. Though this strategy appears complicated, in many respects, professional boxers have been deploying a similar strategy for decades. Boxing and EPM are quite analogous as the goals are similar. Relative to this, the central theme of boxing is to 1) have a thorough understanding of your opponent and 2) exploit their vulnerabilities. At a closer comparison, boxing requires a thorough understanding of your opponent's behavior in the ring and similarly EPM requires a through understanding of the pest's behavior in the cropping environment. A boxer will modify their boxing technique to make the ring less favorable to their opponent; and a farmer practicing EPM will modify their production techniques to make the cropping environment less favorable for pests' colonization, survival and increase. A good boxer will minimize injury despite of being punched and a good farmer will minimize yield reductions in spite of their produce being injured by pests. Though there are similarities between boxing and EPM, an important difference is that a boxer is typically dealing with a single opponent and species in a small ring, and a farmer has to deal with multiple opponents and species complexes in an expanded environment. As such, a good EPM plan is designed with the intent to keep multiple pest species and complexes in check and may target them within and/or outside the crop.

In developing an EPM plan, think of the targeted pest species as perps, and to mitigate, subdue or capture these perps, and prevent future harm to your crop, it is important to research and learn as much about their *modus operandi* (MO) as possible. Successful recognition of a perp's MO can facilitate their rapid apprehension just as successful recognition of a pest species MO can facilitate a successful and rapid mitigation plan. When studying the MO of a pest, there are at least four important features to discern: 1) understand a pest's ecological requisite (needs that are

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Fig. 2. Cerruti thinking intensively and extensively about ecological pest management and conservation biological

essential for their survival), 2) know how available these requisites are, 3) know the location of these requisites and 4) understand a pest's behavior in obtaining these requisites. Major pest requisites can be viewed as potential weak links that can be exploited and used against them, similarly as boxers takes advantage of their opponents' vulnerabilities to win a fight.

Essential necessities such as proper space, refuge from extreme weather and natural enemies, food, and a place to mate and lay eggs are possible weaknesses of pests that can be taken advantage of. Relative to this, an important acknowledgement is that the various needs of insect herbivores and other pests, including pathogens, may occur outside a crop field. Thus, to exploit their weaknesses may require deploying tactics in areas beyond crop fields. An example could be a pest species that requires an alternate host plant such as a weed or shrub when the host crop is not in season; and good *sanitation practices*, specifically removing alternate host plants can make the area unsuitable for their survival. Other potential weaknesses of some pests are that they are monophagous, meaning they are limited to a single host plant and some may lay their eggs in the field in anticipation that their host crop will be planted there the succeeding field season. Some plant-parasitic nematodes fit this MO. However, if the feeding stage is immobile, a simple solution is to practice *crop rotation*. If the immobile offspring hatches and is surrounded by non-host plants, it will likely starve. Another potential weakness of a pest is its preference for a specific host plant cultivar. For example, if we are trying to manage the striped cucumber beetle (*Acalymma vittatum*), which is a pest of cucurbit crops, and learn that it prefers cucurbits with high levels of cucurbitacin, we can surround the main cucurbit cash crop with plants with a much higher level of cucurbitacin to attract this beetle away from the main crop. This tactic which is known as *trap cropping* takes advantage of a species' preference for certain plant species, cultivars or a certain plant stage.

In some instances, a single EPM tactic may be deployed to target various weak links of a pest species as well as multiple pest species and complexes. For example, certain migrating insect pests such as aphids are attracted to areas of high color contrast and can thus better locate a field of host plants by contrasting green plants with the soil background. As such, reducing the amount of bare-soil will reduce the contrast and consequently lower the attractiveness of a field to these insects. This can be done by reducing the *row spacing* and/or increasing the within row planting density which allows the crop to form a closed canopy more quickly. Additionally, dense plantings increase humidity within the crop canopy, creating a less favorable environment for some pests. Notwithstanding, these environmental conditions are also more favorable for an epizootic fungal outbreak targeting pests such as caterpillars, mites and aphids which can cause a rapid decline in their populations. Moreover, increasing the planting density makes the environment less conducive to weed establishment by reducing the number of niche spaces that weeds can use to germinate. Two weak links for weeds include a need for space and light both of which are jeopardized by a denser crop planting and a rapidly closing crop canopy.

Using the *intercropping* or *interplanting* techniques are additional practices that can be used to reduce the area of contrast, enhance humidity and take away niche space from weeds as well as reduce the apparency of a host crop and make it less hospitable to pests. In fig. 1, a combination of a living and dead cover crop mulch is used to make the sweet corn crop less hospitable to weed and insect pests directly and circuitously by attracting their natural enemies. It is known that the pre-pupae stage of the corn earworm (*Helicoverpa zea*) prefers soft tilled soil (*potential weak link*). In no-till soil with plant residue, the MO of H. zea larvae is to spend more time and travel greater distances searching for suitable pupation sites. This extends the period that they are vulnerable to ground predators, many of which are more abundant in vegetatively and residue enhanced habitats. The additional flora and residue will also reduce niche spaces for weeds to germinate in and attract weed seed predators. As such, as part of a NESARE project we are integrating a living mulch and cover crop residue into sweet corn in an attempt to exploit the vulnerabilities of H. zea and weeds. Initial findings demonstrate that this tactic works well in managing weeds and its impact on H. zea is still being scrutinized.

The EPM concept has its rewards and limitations. Some potential advantages include reduction in pesticide use, congenialness to beneficial organisms, compatibility with other management tools as well as organic and conventional farming operations, and ability to often target multiple pests and pest complexes with a single tactic. Further, EPM is generally inexpensive to implement and ecologically friendly. Among some of its disadvantages, the biology of pests (MO) should be well understood. As such, unlike a pesticide label, there are no instructions for the deployment of EPM techniques for various pests or crops. Moreover, it is a preventive tactic and as such, may not control unexpected pest population peaks. Some of the most effective EPM tactics for a particular pest may not integrate well within all farming operations. Still, despite its limitations, EPM is a viable option for managing pest complexes in organic vegetables. Financial support and subject matter for this article is via USDA NIFA EIPM grant award number 2021-70006-35384 and NESARE project LNE20-406R.

Fig. 1. Sweet corn interplanted with a red clover living mulch

SPIRAL PATH FARM: HOW WE MANAGE WEEDS

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Organic weed management entails the use of multiple management techniques. At Spiral Path Farm, we have come to rely on several approaches that yield reasonable results. A basic understanding of weeds, the use of plasticulture, hand weeding, and tractor cultivation provide the bulk of our weed management strategy. There are also some emerging techniques worth exploring in the future.

Understanding weeds

In the Mid-Atlantic region, we are blessed with rain and fertile soils. This combination provides easy germination of any plant seeds when the soil is tilled, as is common in organic vegetable production. Weeds, in effect, are mother natures cover crop. Weeds aid in the protection of the soil from sun and rain. They also can provide a source of carbon for the biology in the soil. On the downside, weeds can reduce yields due to competition for nutrients and water as well as shading. Weeds can also manipulate the microclimate, causing disease issues in certain crops. Weeds can indicate the fertility and structure of a soil; our most productive soils will typically have a higher density of weeds (galinsoga, pigweed, lamb's quarters). Some of our harder soils will have a lower density of weeds (thistle). Fields that are weedy due to a lack of cultivation or hand weeding will ensure a weeder field the following year. Staying on top of weed management pays dividends into the future. It should also be mentioned that the overapplication of nitrogen and phosphorus will encourage more weed growth. Balancing nutrients is good for the environment, your wallet, and aids in weed management.

Plasticulture

Organic and conventional vegetable production in the Mid Atlantic have relied on and benefitted from the use of plasticulture for a few decades now. Covering a portion of the soil with plastic has proven benefits and obvious drawbacks. Organic production, to date, requires the use of non-biodegradable plastic that must be removed every year and sent to the landfill. We use different colors of plastic (silver, green, black, white) depending on the crop and the time of year. In order of weed protection, best to worst, the colors would be ranked: black, silver, white, green. (Green plastic with the addition of row cover seems to be the greatest weed seed germination strategy ever invented. Yet we still do this and will continue with it into the future.) Laying plastic early and letting seeds germinate before holes are punched is a viable strategy to minimize hand weeding around the holes. We choose to lay plastic and plant right away because of the benefits to soil health by delaying tillage to let cover crops grow. This technique then requires hand weeding. We stop laying plastic in mid to late summer and prefer to grow on "bare ground" for most Fall crops.

Hand Weeding/Hoeing

It is common for our crops to get at least one round of hand weeding, with particular crops (onions, carrots, etc.) requiring more than one weeding. Crops grown on plastic typically only get one weeding a few weeks after transplant when they are in full vegetative mode. Crops grown on bare ground are weeded on an as need basis. Summer and Fall crops grown on bare ground (bunching greens, carrots, etc.) will have variable needs for irrigation. Overhead irrigation encourages weed growth more than rain (I do not know why), so we typically try to irrigate bare ground brassicas as little as possible. Before inter-seeding cover crops into Fall planted Brassicas, we usually send a crew through with hoes to quickly knock back larger in row weeds missed by tractor cultivation.

Tractor Cultivation

Most crops grown on plastic require tractor cultivation as well. We typically make a pass with an old 3 point International tine cultivator to loosen the soil. As second pass is then made with a Hillside Cultivator. All 3 point equipment is mounted to a Slider than provides lateral movement for precise equipment placement during transplanting and cultivation regardless of slope and terrain. Some plasticulture crops require multiple rounds of cultivation a few weeks apart (peppers), while others require none (salad). Bare ground bunching greens are transplanted with a water wheel transplanter. Irrigation is added only if plant death is imminent. Cultivation is done on an as need basis depending on weed pressure. The first pass will typically be made using a Cult/Kress finger weeder for in-row weeds. The second pass will then be made using a Danish tine cultivator. Both setups are belly mounted to an Allis Chalmers G.

Emerging Strategies

Soil health and its relationship to plant, animal, and human health have been well documented. The biological links between microorganisms in the soil and plant roots helps to foster better yields of healthier plants. By tilling (or at least over tilling) the soil, we tend to reduce the fungal component of soil biology. Therefore, we prefer to till as little as possible and still achieve yields that provide financial incentive to stay in business. We have not experimented with organic no till production. We have, however, tried strip till. This technique tills a narrow 6"+/- strip into a rolled and crimped cover crops. The theory being you can avoid tilling a large portion of the field, while still cultivating a narrow strip of in-row weeds. Weeds that emerge through the cover crop or cover crop that has not completely been terminated can be rolled again as a sort of cultivation. This technique is in its infancy, but has provided us with encouraging results in bunching greens. We look forward to trying more strip tillage in the future. Working out the details of fertilizer placement, irrigation, and proper equipment set up for in-row cultivation are critical to stip tillage's success.

FUNGICIDE RESISTANCE IN MAJOR PATHOGENS ATTACKING STRAWBERRIES

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Resistance to commonly used fungicides have been widely reported in important fungal pathogens affecting strawberries. The risk of resistance development varied greatly between fungicides and between fungal species. In general, protectant fungicides such as Captan and Thiram with multi-site activity are much less prone to resistance development, compared to fungicides attacking a single metabolic site of fungi. However, single-sites are typically favored in the integrated pest management due to their reduced risk, partial curative activity and improved rainfastness. Fungicide Resistance Action Committee (FRAC; https://www.frac.info/) uses letters and numbers to distinguish the fungicide groups according to their cross-resistance behavior, and those with multi-site activity are indicated by the letter 'M' in their FRAC codes.

Anthracnose crown and fruit rot

In the mid-Atlantic region, anthracnose crown rot (ACR) was mainly found to be caused by *Colletotrichum siamense* within *C. gloeosporioides* complex or *C. nymphaeae* within *C. acutatum* complex. In contrast, anthracnose fruit rot (AFR) was caused by *C. nymphaeae* almost exclusively. Quinone-outside inhibitors (QoI; FRAC mode of action group 11) are the primary fungicide class used for both ACR and AFR control. Methyl benzimidazole carbamates (MBC; FRAC 1) fungicides are typically effective against *C. gloeosporioide*s but not *C. acutatum* complex species. Bioassays were performed to test for resistance to azoxystrobin (QoIs) in all the 200 isolates we collected from mid-Atlantic region strawberries. Overall frequency of resistance to azoxystrobin (QoIs) was 42%. Moreover, all *C. gloeosporioides* complex isolates were additionally screened for resistance to thiophanate-methyl (MBCs), and the overall frequency of resistance was 64%. These results indicate that QoI or MBC fungicides may no longer be effective against Colletotrichum spp. in the region.

Botrytis fruit rot (also known as gray mold)

There are two main Botrytis species found affecting strawberries in the Eastern US, including *Botrytis cinerea* and *Botrytis fragariae* (a recently discovered species). While *B. cinerea* is often isolated from both flowers and fruit, *B. fragariae* is most often isolated from flowers. Field isolates of both species have been found resistant to multiple chemical classes of fungicides. *B. fragariae* seems to be naturally more tolerant to fludioxonil (product name: Switch or Miravis Prime) and polyoxin D zinc salt (Ph-D or OSO). Higher frequencies of resistance to both active ingredients were also detected in *B. fragariae* populations. However, frequency of *B. cinerea* resistant population to boscalid (Pristine), penthiopyrad (Fontelis), cyprodinil (another component in Switch), iprodione (Rovral), or fenhexamid (Elevate) was relatively higher than that of *B. fragariae*. Overall, fludioxonil and newer SDHIs (FRAC 7; such as Kenja, Luna series, and Merivon) seem to have less potential resistance issues at this time.

Phytophthora crown and fruit rot

The disease is typically caused by *Phytophthora cactorum*. Another species *P. citricola* has also been reported causing both the crown and fruit rot (i.e. leather rot). More recently, P. nicotianae has been identified to infect the crown and fruit as well. It is not uncommon for Phytophthora species to develop resistance to mefenoxam (Ridomil Gold). The resistance was first reported in P. cactorum isolates from a strawberry field in South Carolina. A study conducted in Florida has detected a shift towards higher frequency of resistance in the *P. cactorum* population. Currently, azoxystrobin (QoIs; FRAC 11) is labeled for control of leather rot but not for the crown rot. Resistance to azoxystrobin in *P. cactorum* and *P. nicotianae* has been recently reported in Florida strawberry fields for the first time. Fosetyl-alumi-

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num and the phosphite products are considered low-risk fungicides for resistance development and should be used for the integrated disease management.

Powdery mildew

Strawberry powdery mildew is caused by the biotrophic pathogen *Podosphaera aphanis*. The disease is easier to control but harder to detect at the early plant growth stages. Once the infection has well established and advanced, it becomes difficult to control. Although resistance to demethylation inhibitor fungicides (DMIs; FRAC 3) in the pathogen has been widely reported in Europe, no characterization of resistance to any fungicides was done in the US until recently. A total of 19 isolates collected from multiple commercial production fields and a nursery in California has shown resistance to SDHIs (FRAC 7), quinoxyfen (FRAC 13), and DMIs. Additionally, a fewer isolates seemed to have also developed resistance to QoIs (FRAC 11) and cyflufenamid (FRAC U6) based on lab assays. Results from the greenhouse trials were well correlated with that of lab assays, suggesting that resistance in *P. aphanis* to commonly used fungicides may be widespread, especially in areas where fungicides have been frequently used for powdery mildew management.

Fungicide resistance management

The key to managing resistance issues is spraying less single-site fungicides. When weather conditions are less favorable (no extended moisture) for disease infection, consider extending spray intervals. The best fungicides are not as good as good weathers.

- Primarily use low-risk fungicides or protectants (multi-site activity) for controlling pathogens in which resistance is a concern. This is especially important when the plant growth stage is highly susceptible to disease infections (i.e. flowering/fruit ripening)
- Tank-mix a low-risk fungicide with a high-risk (single-site) fungicide when disease pressure is high.
- Limit each FRAC code (except for multi-site fungicides) to two applications per growing season.

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NEW STRAWBERRY VARIETIES FROM NCSU AND OTHER BREEDING PROGRAMS

Mark Hoffmann, Rocco Schiavone & Gina Fernandez
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General Recommendations:

- Obtain plants from at least two nurseries to compare productivity and spread-out the risk of disease introduction from a nursery.
- Plug plants need to have a well developed root system. Inspect your plants for root development and foliar disease symptoms before planting. Do NOT plant plug plants of low quality. Order 5% more plants if needed for replacements.
- Bare-root plants need to be planted 1-2 weeks earlier and require over-head irrigation.
- If you are trying new cultivars that you have not grown before, it is important to first trial small plantings (50-200 plants) on your farm for a minimum of 2 seasons, before you place large orders.

The standards

These short day or "June-bearing" cultivars are used widely throughout NC and the Southeast for several decades and have been the 'backbone' of the strawberry industry in NC.

Sweet Charlie (University of Florida, 1992):

Short day. Early season. Medium size fruit, low yield. Good flavor, soft fruit. Good for early pick-your-own and other direct to consumer sales. Crop can be lost due to early flowering. Will produce a second flush of fruit near the end of the season. Not rain tolerant.

Chandler (UC Davis, 1983)

Short day. Mid-season. Medium size fruit, moderate to high yield that has steady production through the season. Good flavor and soft fruit. Best for pick-your-own and other direct to consumer sales. A standard cultivar in NC for many years. Chandler is adapted to many regions. Berry size can vary, and the plant can produce small berries. Not rain tolerant.

Camarosa (UC Davis, 1992)

Short day. Mid-season. Medium size fruit, moderate steady yield through season. Good flavor especially at the end of season. Best for pick-your-own and other direct to consumer sales. Fairly suitable for wholesale. A standard cultivar in NC for many years. Smaller berry size at end of season, but better flavor. Berry deformation in early season common. Fairly rain tolerant.

Alternative cultivars to consider

These cultivars have been trialed in research and on-farm trials in NC and other states and have been used successfully in commercial production in recent years. Listed from early to late season.

Rocco (NC State 2018):

Short-day. Early season. Medium size fruit, steady yield through season. Soft and very good flavor. Seeds sometimes at or on the surface of fruit. Best for pick your own and other direct to consumer sales. Consider as a Sweet Charlie alternative. It will start at same time or before Sweet Charlie and will continue to fruit through the season. It is very popular in the mid west. Berry size can vary.

Dr. Fernandez received a Ph.D in Pomology from Cornell University and a M.S. in Horticulture from the University of Minnesota. In between her graduate degrees, she worked with Drs. John Clark and Jim Moore at the University of Arkansas as a research assistant to the small fruit breeding program. She has been at North Carolina State University since 1996, where she is currently an Associate Professor/Small Fruit Specialist in the Department of Horticultural Science. Dr. Fernandez has a 70% extension and 30% research appointment with responsibilities for small fruit crops in all regions of North Carolina. She also teaches the Small Fruit Production class every other spring.

Ruby June (Lassen Canyon):
Short-day. Early to mid season. Very good flavor, moderately firm, steady yield through the season Good for pick your own and other direct to consumer sales. Good for wholesale. Consider as a Chandler alternative. Planting date comparable to Chandler is very important to achieve good yields. Good rain tolerance.

Camino Real (UC-Davis 2001):
Short-day. Early to mid season. Medium size fruit and high yield. Fair flavor, firm berry. Good for whole-sale or pick your own. Disease tolerant. Good rain tolerance.

Liz (NC State 2018):
Short-day. Mid to late season. Medium size fruit and high yields. Moderately firm, with improving flavor in late season. Best for pick your own and other direct to consumer sales. Consider as a Camarosa alternative. In some locations can develop large canopy. Fair rain tolerance.

Merced (UC Davis 2014):
Short-day. Mid-season. Large fruit with moderate to high yield. Fair flavor and firm. Small canopy is easy to see fruit to pick. Best for direct to consumer sales and whole sale. 12-inch planting space recommended. Higher N recommended in spring. Due to small canopy, sunburn is very common. Not rain tolerant.

Fronteras (UC Davis 2014)
Ever-bearing. Large berry and high yield. Firm fruit and fair flavor. Plants need more nitrogen during spring. Good for direct-to-consumer sales and whole-sale. For fall production, plant mid-August to early September. Flavor and color can be an issue. Not rain tolerant.

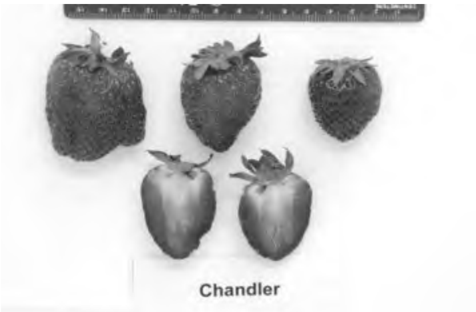
Radiance (University of Florida, 2008):
Short-day. Early to mid season. Medium size, and fair to poor yield. Fair flavor and firm, and poor-fair yield. This cultivar (and most of the University of Florida cultivars) flower during the winter and yield will be reduced from loss of early blossoms to cold events. Once season starts, it is a relatively steady producer. Can be used under tunnels. Not rain tolerant.

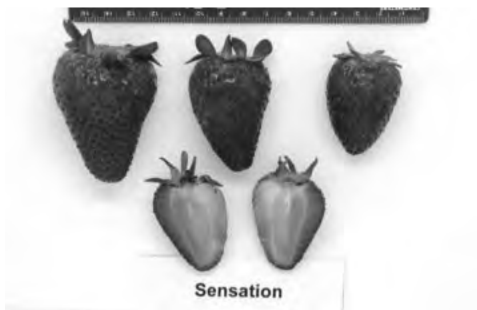
Ever-bearing cultivars:

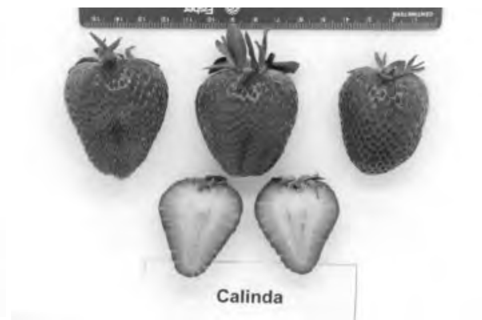
Albion (UC Davis 2004):
Ever-bearing. Medium to large size, moderate yield in spring, can produce fruit through the season. Good to very good flavor. Good for extended season/low tunnel/high tunnel/greenhouse. Good for direct-to-consumer sales and whole-sale. Plants need more nitrogen in spring. For fall production, plant mid-August/begin of September. Attracts two-spotted spider mites. Not rain tolerant.

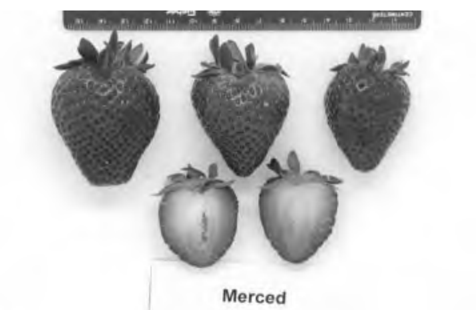
Monterey (UC Davis 2008):
Ever-bearing. Medium-large berry, and medium-high yield. Very good flavor and firm. Good for extended season/ low tunnel/high tunnel/greenhouse. Good for direct-to-consumer sales and whole-sale. Plants need more nitrogen during spring. If in fall production, needs to be planted mid-August/begin of September. Not very rain resistant.

As part of our breeding trials, "newer" cultivars from UC Davis, UFL programs and Lassen Canyon have been trialed at one or more research stations in North Carolina. Yield data can be found at the NCSU Strawberry Breeding Portal https://strawberries.ces.ncsu.edu/straberry-breeding-progam/replicated-cultivar-and-selection-breeding-trials/









CONTAINERIZED DAY-NEUTRAL STRAWBERRY PRODUCTION - WHAT WE'RE LEARNING

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As new disease problems emerge and weather-related uncertainty increases, interest (and acreage) in protected culture systems for strawberry production is on the rise. Protected culture helps with avoiding and/or reducing the presence of difficult-to-control foliar and fruit diseases, and reduces the need for fungicide spray applications – an important advantage as we see more disease resistance issues emerging related to chemical fungicide use.

Containerized production with soilless media is used not only in greenhouse production, but also may have a place in high tunnels as soil-related issues surface over time. These issues include soil compaction, salt buildup, and potentially soil-borne diseases because of short breaks between production cycles and limited crop rotations.

Over the past several decades, some growers have tried an assortment of containerized production systems and met with varying levels of success. Usually, these first attempts have been small-scale. However, when issues have arisen, growers often find that their ability to identify and solve the problem, as well as other's including most extension personnel, is less than what they need. This is due to the newness of the systems and lack of experience on everyone's part, but also each attempt usually introduces some new variable(s) that make it difficult to sort out and understand the problem's cause.

What We've Tried

In an attempt to better understand these systems ourselves, we've been experimenting with an evolving set of containerized production methods. The long-term goal is to develop a relatively low-cost grower-friendly set of recommendations that would be easily adoptable.

Rock Springs Horticulture Research Farm. From 2015 through 2019 at Penn State's high tunnel facility, we compared grow-sleeves vs. grow-bags, incorporated fertilizer vs. soluble fertilizer, different media types, and different varieties of day-neutral strawberries in replicated trials. During 2003 to 2004, we had also looked at production of June-bearers and day-neutrals in a gutter system, but at that time, thought that the economics were not likely to result in immediate adoption. Over the years, we trialed 13 varieties of day-neutrals, and 8 June-bearers. June-bearers weren't productive enough over a long enough season to warrant the effort, and 'Albion' had the best combination of high yields and high quality.

For both sets of experiments at Rock Springs, a major complicating factor was that our well water had a high pH (7.8) and high bicarbonates at 270 mg/L total alkalinity as $CaCO_3$; that is 2.7 times higher than the threshold for being a level for concern. Even though this was much higher than recommended, we felt it was necessary to avoid using concentrated acid to acidify the water due to safety and chemical storage concerns.

Kathy Demchak has been at Penn State since 1983, and currently works in berry crop research and extension statewide. She earned a B.S. in Horticulture from Penn State and an M.S. in Horticulture from Virginia Tech. She lives in a rural area of Centre County with her husband Steve.
Timothy Elkner is a regional horticulture educator based in Lancaster County, PA. His prime areas of responsibility are commercial vegetable and fruit production. He conducts applied research on vegetables and small fruit with an emphasis on variety evaluations. He has a B.S. degree in Agricultural Sciences from Cook College (Rutgers University) and an M.S. and Ph.D. in Horticulture from Clemson University and Virginia Tech, respectively.
Krystal Snyder is with Penn State Extension in Northampton County. She previously was a Technical Specialist at JR Peters. Since she was young she considered herself a serious plant nerd, which led her to Delaware Valley College, where she made it official by earning a B.S. in Horticulture. When not helping customers fix their plants or creating her own outdoor oasis, Krystal can be found restoring her century old house in Easton, PA, with her handyman husband Justin, daughters Alexia & Lucy, and their two crazy Australian cattle dogs.

Despite this, we were eventually able to produce high yields averaging 2.0 to 2.4 pounds of fruit per plant from 'Albion' after several less-than-successful attempts. We attributed the success to adopting the use of a well-drained and somewhat coarse media that also didn't dry out too quickly combined with a constant-feed fertilizer solution. The media that we used was a 2:1 horticultural peat:coarse perlite mix that did not have lime added to it. It started out with a pH of 4.8, which is much lower than what is normally recommended, but ended up at 6.4 by the end of the growing season due to watering with our high bicarbonate water. We used a fertilizer source made for high bicarbonate water at 100 ppm N (Plant Marvel 20-7-20), which dropped the fertigated solution pH by a little more than a pH unit from 7.8 to 6.6-6.8. Media we tried that did not work well included coir, which resulted in symptoms of salt burn (though leaching with a calcium nitrate solution instead of water alone may have avoided this problem); a less porous media (Metromix 360) which resulted in reduced root growth; a mix of peat, coir and perlite; and a 60:40 peat:perlite commercial mix with lime. This last media likely had too high of a pH for our situation, as we battled iron and zinc deficiencies until fall when we finally corrected them by repeatedly adding iron and zinc chelates and acidifying the fertilizer solution.

Southeast Research and Extension Center, Landisville. This location has a warmer environment than Rock Springs, but is in the part of the state where many of our strawberry growers are located. Because day-neutrals are not supposed to be tolerant of hot conditions, we expected that yields could be lower than at Rock Springs, and wanted to know if that would be the case before recommending this system to growers.

In this experiment, we compared seven different types of growing media using the cultivar Albion. Six of these media were commercial mixes, as we heard from growers that having a pre-mixed media was greatly preferred over mixing their own due to time and labor needs. We used the same fertilizer source as we had at Rock Springs. The well water at Landisville was similarly high in pH and bicarbonates, though not quite as bad, with a pH of 7.5 and total alkalinity of 221 mg/L. We didn't start acidifying our water right away, hoping we would be able to avoid doing this as we had at Rock Springs, but this time doing so didn't end well. We did again use the same fertilizer for high bicarbonate water, but found that when using media types that contained added lime, as in earlier experiments, the plants quickly developed symptoms of iron deficiency and tissue iron levels which were in the deficient range. Even tissue iron levels in plants without symptoms, which were 30% higher, were still in the deficient range. We started acidifying the water in early August using sulfuric acid; but iron deficiency symptoms never did improve, so perhaps we needed more sulfuric acid than calculations indicated.

Despite all of this, yields were higher than we expected. The 2:1 peat:perlite mix didn't perform nearly as well at Landisville as it did at Rock Springs, but the plants in this media still produced total yields of 1.4 pounds per plant.

The best performing media was BC-5++ from BVB Substrates in the Netherlands. Total yield from plants in this media averaged 2.1 pounds per plant, with a mean berry weight of 13.9 g/berry (a large berry). This media, as was the case with the peat:perlite mix, seemed to have a good combination of high porosity and water-holding capacity. It was different from the rest in that it had peat chunks that were lumpy and somewhat spongy, and you couldn't compress the media even if you tried to. The peat in this mix is referred to as "white peat", which was a new term to us, and is listed on the bag as "slightly decomposed raised bog peat".

Yield from other commercial mixes, despite varying degrees of iron deficiency, were intermediate and all quite similar to each other, varying between 1.61 to 1.77 pounds per plant.

The pH of leachate from the BC-5++ media was the lowest of all commercially available mixes, averaging 6.7, which was still higher than we would have preferred. The pH of leachate from other commercial mixes ranged from 6.9 to 7.2.

What We Learned

What we learned from these experiments was that 1) media that is well-aerated and well-drained is best, 2) we may need to find a media that doesn't have added lime especially in high bicarbonate water situations, as this compounds problems with iron deficiencies, 3) we likely need to acidify the water source and fertilizer solution from the start of the growing season in high bicarbonate water situations, though whether we absolutely would need to do this if we had a media without added lime is still a nagging question, 4) we need to explore the use of fertilizers that have more iron available from them in the correct form(s), and 5) there probably are some different combinations of media types and fertilizers that would work well together for most situations, but there probably won't be a one-size-fits all solution.

What's Next

Fortunately, there are some new fertilizer products on the market now that may help to solve some of these problems, so we hope to look at more options during the next growing season in an experiment that combines media type and fertilizer type. Our plans are to monitor what is happening with the water source, in the pots, and in the plants much more closely so we can track what is happening over time, and share this information as we learn.

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MICROCLIMATE AND DISEASE RISK UNDER ROW COVERS FOR STRAWBERRIES

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Strawberry plasticulture production in the U.S. uses an annual hill system, where young plants are transplanted in early fall into raised soil beds, which are covered with black plastic mulch. Plasticulture growers in production areas outside Florida and California such as the coastal plain or piedmont areas of the eastern US, typically use lightweight spun bound or nonwoven row covers to promote floral bud initiation (degree-day accumulation) in late fall, as well as frost or freeze protection in spring. Growers in colder climates such as the Appalachians or the Midwest use row covers to protect their strawberry crop over longer periods, from December into March, as well as during cold snaps throughout flowering. Current IPM tools are typically not designed to monitor environmental variables at the canopy-level. Understanding weather conditions within plant canopies, with or without row covers, is valuable for risk management throughout the production period.

During the 2019/20 and 2020/21 strawberry growing seasons, canopy-based sensor stations with multiple environmental sensors (Meter Group Inc., Pullman, WA) were installed at four farms in Maryland and Virginia. Five-minute resolution temperature and leaf wetness duration data from these stations informed the disease models previously developed for anthracnose fruit rot (AFR) and Botrytis fruit rot (BFR) and incorporated into the cloud-based AgZoom software (Verdu, Spain). A two-year evaluation of this microclimate-based disease forecasting system was conducted in each location. Fungicide treatments were arranged in a randomized complete block design, and applications were based on three strategies: (1) predictive data from canopy-based sensors (CBS), (2) predictive data from an on-farm weather station (ATMOS 41 sensors, installed at the side of the field at 6 ft height), and (3) grower standard (GS) sprays. GS plots were sprayed every 7 to 10 days, depending on weather conditions. For the ATMOS and the CBS treatments, fungicide applications were independently guided by the risk determined from each disease model output, starting at bloom. AFR and BFR incidence and marketable fruit yield were determined every week. The main goals of this study were to understand differences among environmental variable inputs and increased model precision due to sensor placement and to validate the canopy-based disease risk models for timing fungicide applications to control AFR and BFR.

Leaf wetness. In general, the leaf wetness duration tended to be longer at the canopy-level compared to the weather station locations. Among the canopy-level sensors, there were no specific patterns observed regardless of their placement on the edge row, the non-edge row, within-rows or between years. During the fall row cover period, the covered sensors generally had shorter wetness durations than non-covered sensors. Based on our preliminary data

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Dr. John Lea-Cox is a Professor in the Department of Plant Science and Landscape Architecture at University of Maryland College Park. As a researcher and extension specialist, John has specialized in water, nutrient and pathogen management issues in intensive nursery, greenhouse, urban and controlled environment production systems since 1993. His research and extension programs strive to provide people with real-time information from their own crop production systems, utilizing sensor networks and smart software to inform practical solutions. His intent is to help people make better production decisions, conserve resources, improve their profitability and reduce the environmental impact of their production practices.

Dr. Jayesh Samtani is an Assistant Professor in the School of Plant and Environmental Sciences at Virginia Tech., and is located at the Hampton Roads Agricultural Research and Extension Center. He has a research and extension appointment in small fruit production and his program is currently focused in the areas of biofumigation, variety evaluations, season extension and supplementary nutrient application.

analysis, there seems to be a seasonal effect on the leaf wetness at the canopy level, and that location differences are likely due to differences in wind patterns within and between locations and different days. During fall and early spring, the longer wetness durations in the canopy seemed to be more pronounced compared to that of winter and late spring or early summer.

Temperature. There were no statistical differences in the average air temperature between the canopy-level sensors and weather station sensors based on our preliminary analysis. Similar to the leaf wetness durations, no specific patterns were observed between sensor locations in the canopy. However, as expected, the use of floating row covers significantly increased the canopy-based air temperatures during both the fall and winter covered periods, compared to the ATMOS sensors. In addition, row covers applied during the fall resulted in significantly higher average air temperatures and degree-day accumulations, compared to the non-covered canopy or ATMOS sensors.

Infection risk. The infection risk for AFR and BFR tended to be lower using the ATMOS sensor predictions compared to the canopy level predictions, leading to more infection events for the latter. These infection events triggered more fungicide applications to the CBS treatment than the ATMOS treatment, yet both treatments resulted in fewer applications than the GS treatment. Differences in AFR and BFR incidence were observed at two sites in 2019/20 and 2020/21 seasons, where the GS and CBS treatments had the least average disease incidence. Most importantly, marketable yields were comparable between all treatments.

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AN INTRODUCTION TO LONG CANE RASPBERRY PRODUCTION

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Container production of long cane raspberries in protected culture is a growing industry in Europe and Canada. In these areas, container culture allows growers to produce higher quality fruit over a significantly expanded harvest window compared to the field. Growers are increasingly turning towards container production as a way to take advantage of higher prices in the market, avoid soil borne diseases and utilize otherwise marginal land.

Research is being conducted in southeastern North Carolina to determine if this production system can be adopted here. Raspberries are a high-value crop that are not currently grown commercially in this region. Disease pressure and high temperatures during the natural harvest window result in reduced fruit quality and short-lived plants. The use of containers, early harvest through protected culture in high tunnels, and an annual production system may overcome these challenges and make this a viable enterprise. We are also investigating the use of two substrates – coco coir and a pine bark blend that could be produced locally. Development of a locally available substrate would reduce supply chain concerns while being less expensive and more sustainable.

long cane raspberry production system, primocanes are grown in a nursery, either in containers or in the ground. In the fall, these plants (the "long canes", Figure 1) can be lifted and moved to a cooler. Production of the primocanes can happen in an entirely different location than fruit production.

At the desired time, the dormant long canes (Fig. 1) are removed from the cooler, potted up, and set out in high tunnels (Fig. 2) to produce fruit. Timing of pullout from the cooler permits the grower to schedule harvest for the appropriate environmental and market window for his area. This allows the grower to capitalize on higher early or late season market prices or provide local raspberries where they could not otherwise be offered.

Fig. 1: Dormant canes

Fig. 2: High tunnel range

Fig. 3: Fertigation monitoring station

Lisa Rayburn is currently employed with North Carolina State University as an area extension agent. She has responsibility for commercial horticulture working with fruit and vegetable growers in a four county area in southeastern NC. Lisa is also a Master's student at NCSU in the Horticulture Department working with Dr. Gina Fernandez. Her research is focused on the potential for the development long cane raspberry production system for southeastern North Carolina and the development of a locally sourced pine bark substrate.
Lisa's background includes teaching horticulture at the community college level as well as managing production greenhouses and a plant tissue culture lab. Lisa was raised in WV, completed her bachelor's degree at West Virginia University and she is excited to be presenting here in the Mid-Atlantic Region.

During the production cycle, high tunnels must be monitored daily with attention paid to venting and freeze protection as well as closely monitoring irrigation and fertilization (Fig. 3). The time from pull-out to harvest is approximately 90 days but can vary depending on the variety and timing of pullout.

Fig. 4: Bud break

Fig. 5: Flowering

Fig. 6: Fruit set

Fig. 7: Harvest

STRAWBERRY PRICING CONSIDERATIONS AT SHENK'S BERRY FARM, LITITZ PA

John Shenk, Shenk's Berry Farm

After selling picked strawberries for about 40 years, we have focused on doing only pick-your-own. This was primarily because we could no longer keep up with managing teenage pickers and doing pick-your-own at the same time. Since we do not have a farm market it is not quite the same as it would be if we needed to supply a store which also sold other fruits and vegetables.

Over the years we have intended to be a farm which provides a fairly simple picking experience rather than an entertainment type of farm. So, we are most interested in serving people who come to pick a larger amount of strawberries for freezing or preserving the berries for the rest of the year. We do have a number of customers who will come multiple times throughout the season for a regular supply for eating in season.

Before Covid, we sold all the berries for a flat rate of around $1.75 a lb. With the original uncertainty about the possibility of transmitting the virus through surfaces, we switched to using a tray which hold 6 quart boxes. Last year we were charging $3.25 a Qt. which was a slight increase over the $1.75/lb. plus the cost of the tray which had been $.75. The idea was that if a family came with several pickers, each could have their own Qt. box and then set them in the tray. It is not as equitable a system as weight but is much easier to handle customers. The price will probably need to be increased this year just to cover the increased cost of materials.

The perennial problem for Pick-your-own farms is when a large group comes, who take up rows in the field but do not pick very many berries. Some farms have gone to an admission charge. We as a family have not agreed on way to address this issue, but at some point may need to go to a tiered pricing structure. It is just hard to weigh all the factors involved: might someone who came and picked only a few berries someday come back for many more or give a positive recommendation to a prospective new customer. So we attempt to be conscious of the overall experience pickers will have, bearing in mind that there will always be some difficult customers. But in the end, did people leave satisfied and will we have enough income to justify the effort.

VIRTUAL TOUR AT CATOCTIN MOUNTAIN ORCHARD

Robert Black, Catoctin Mountain Orchard

Welcome to Catoctin Mountain Orchard located 1 ½ miles north of Thurmont, MD or 20 minutes south of Gettysburg, PA. Our retail market can be accessed right off of rt. 15 making it an ideal location. The majority of our crops are sold at our retail farm market May 1st- Dec. 31st. A fraction of sales come from u-pick and seasonal tailgate marketers. For over 10 years we have supplied 64 public schools in Frederick County from August to May. Apples are what started us in the school lunch program and have since grown to supply them with peaches, nectarines, pears, kiwi berries and plums. The farm consists of 100 acres with 25 acres of apples and 25 acres of peaches being our two main crops. Rich loamy soils on the Eastern slope of the Appalachian Mountains are great for all of our crops. Our lower ground has clay subsoil that was key in building good water holding ponds. The four irrigation ponds that were built in the early 60`s give us approximately 6 acres of water capacity. Two electric powered irrigation pump sites with sand filters are able to schedule water on our crops as the seasons progress. Plastic cultured strawberries, early vegetables and several varieties of apples carried over from our fall crop gives us a nice selection in our market when we reopen in May 1st. Sweet and Tart Cherries, Black Raspberries, Blueberries are available for pick your own mid June through August 1. A half acre of cut-your-own flowers on plastic has become very popular for all ages. Three acres of Apricots and many varieties of Japanese Plums and Peaches are a great draw to bring in customers. A wide selection of white and yellow peaches and nectarines starts July 1st to the third week into September. One acre of Blackberries are harvested by our men and sold in our market. Many of our new apple varieties have come from the Midwest Apple Improvement Association. Several of these include: Summerset, Evercrisp, Ludacrisp, Crunch-a-bunch, Rosalee as well as a few numbered varieties to test. Three acres of pears that include Bartlett, Seckel, Bosc and Magness. A half acre of Kiwi Berries and one acre of Grapes, that consist mostly of Concord, give customers more to select from. Our u-pick apples start the last weekend in August and goes anywhere from the last weekend in October to the second weekend in November weather permitting. Saturday and Sundays are our only u-pick apple days and our hours start at 10-3 and as we get further into the season, we go an extra hour. We have been doing u-pick apples for 7 years and each year we gain more business. The 2020 u-pick apple season was the busy time ever! Each weekend of apple picking we try to have over 3 or more varieties for our customers to choose from. Our u-pick favorites include: Crimson Crisp, Cortland, Evercrisp, Goldrush, Pink Lady, Fuji and Stayman. We no longer grow any Red Delicious because of all the other great varieties we offer. Catoctin was lucky to find a limb sport off of a regular Gala tree many years ago. The patent name is Harry Black Gala, in memory of my father who died in Jan. 1998. However, the trade name is Autumn Gala which ripens three weeks later than the regular Gala making it a great variety for u-pick.

I would like to give credit to my family starting with my sister Pat. She and I are the 2nd generation and current owners. Pat manages our market while I oversee more of the farm plus help at the market as needed. Our full-time staff include my son Christopher (3rd generation), granddaughter Katlyn (4th generation) and Robert Dewees (field foreman). Granddaughter Kylie (4th generation) is working part time while she attend Frederick Community College. My longtime crew supervisor and friend, Guadencio Gonzalez who will be starting his 35th year with us this March. Gaudencio's son plus 2 brothers and 4 of our H2A workers make up our seasonal orchard help. Our seasonal market staff are just as important since they are greeting customers, boxing produce, answering questions, stocking shelves, & making the Cash Register "Sing"! And Pat LOVES THAT!

Robert is a second- generation fruit grower and president of Catoctin Mountain Orchard, Inc. near Thurmont, Maryland. The family-owned farm consist of 100 acres of fruit, berries, and vegetables. 85-100% of the crops are sold at their retail farm market. Robert serves on the Maryland Apple Promotion Board, Maryland State Horticultural Society, serving as treasurer, Past President of the Thurmont Cooperative, Board member for the International Fruit Tree Association, Agriculture Business Council of Frederick County Economic and Development, Tourism council of Frederick County, & Frederick County Farm Bureau. He was the 2020 Apple Grower of the Year

His and his family were selected ''Farm Family of the Year for Frederick County'' for 2006, which wife, Frances, son, Christopher, daughter, Jacqueline and four grandchildren: Katlyn, Wyatt, Nathan, and Kylie. A sister, Patricia Black, secretary-treasurer of Catoctin Mountain Orchard.

A huge change was made at our retail Market in 1983 when we built a 50' X 50' addition that moved our selling area from the 8 garage door porch to an in door Heated & Air Condition building. That move plus a Blacktop Parking Lot increased our business by allowing customers to shop in comfort. Our staff also appreciated the AC in the summer and the warmth in the winter. The staff grade and boxed Fruit on the inside “U” shape design, while customers shopped on the outside of the “U”. Customers can easily shop and ask questions while watching staff pack fruit. A 4 door “reach in cooler” was added for Apple Cider, Local Cheese, Flavored Drinks, & Bottled Water.

A “Bake Off” Bakery was added several years ago to compliment the Fruit, Berries, & Vegetables. Another Oven plus more Freezers have been added to keep up with the demand for Fruit Pies, Cookies, Fruit Breads, Crumb Cakes, & Apple Cider Donuts. Local “Crafters” bring in Pottery, Hand Made Baskets, Hand Sown Aprons, Place Mats, Tea Towels, Wooden Cooking Utensils, plus framed Photographs make up our Gift selection.

Thoughts of adding on for more retail area are on hold due to major “Environmental & Safety” concerns here in Frederick County. A Solar Roof project was added this summer to half of our southern facing roof. A new metal standing seam roof is being plan to the other south half so more Solar Panels could be added there next Spring to help reduce our Electric Bill.

I Thank All of my Family & Staff who get things done while l travel to attend Meetings to look for the next new project for Catoctin! Call my cell at 240-409-7491 or email me at hbgala@aol.com if you have some questions. Thank You. Robert Black, President.

LET THE SUNSHINE IN: AN ASSESSMENT OF REFLECTIVE GROUNDCOVERS IN BLACKBERRY PRODUCTION

Tom Kon, NC State University Mountain Horticultural Crops REC, 455 Research Drive, Mills River, NC 28759

In most temperate fruit crops, inadequate light distribution can have negative effects on productivity, fruit quality, and flowering. Light distribution is primarily managed in blackberry production systems by pruning and training. Without adoption of narrow, planar pruning and training systems, blackberry canopies have a complex, disorganized architecture with poor light distribution in the lower canopy. Inherent vigor of blackberry, particularly in the southeastern US, can result in excessive shading of the interior and basal canopy. Additionally, shaded portions blackberry canopies can provide a microclimate conducive to insect infestation and pathogen development. In other Rosaceous cropping systems, reflective groundcovers had profound impacts on vegetative growth, productivity, and fruit quality. Reflective groundcovers are not to be confused with plastics and organic materials that are frequently used as a weed barrier, or reflective films (mylar). Reflective groundcovers are woven textiles composed of polymers that are designed to be durable (can withstand orchard traffic) and can be used across multiple seasons. These groundcovers reflect light from the orchard floor and enhance light distribution in the lower canopy. In addition to reflecting photosynthetically active radiation (PAR; 400-700 nm), some of these groundcovers reflect ultraviolet radiation (UV; 250-400 nm). We previously evaluated several different commercially available reflective groundcovers over a two-year period in apple. All reflective groundcovers evaluated reflected similar levels of PAR, but UV reflection varied widely among groundcovers. To the best of our knowledge, caneberry research with reflective groundcovers has been limited, unreported, and/or is proprietary. Research on red raspberry in New Brunswick, Canada demonstrated that season-long deployment of reflective groundcovers dramatically altered the canopy microclimate in Rubus production systems. Additionally, use of reflective groundcovers increased marketable yield (48%)and fruit weight (11%) relative to an untreated control. Combining reflective groundcovers with rain shelters increased the marketable yield of raspberries by 67%, suggesting potential utility in high tunnel production systems.In short, the deployment of reflective groundcovers dramatically alters the canopy microclimate and could have many interesting and/or potentially useful responses in blackberry production. To our knowledge, this technology has not been formally evaluated in the southeastern US on blackberry. To determine if this technology has merit in blackberry production, we conducted a preliminary assessment of reflective groundcovers (Extenday® DayBright and Lumilys® WH-100) in floricane and primocane production systems. Treatments effects on canopy microclimate, fruit quality, yield, pest and disease incidence, and vegetative growth were determined. The reflective groundcovers evaluated had profound impacts on canopy microclimate (PAR and UV light, temperature, and relative humidity). Both reflective fabrics evaluated reflected similar levels of photosynethetically active radiation (PAR; 400-700 nm). Extenday® reflected the highest level of UV radiation of all treatments (>36 µmol·m-2·s-1), however, Lumilys® reflected significantly higher levels of UV (13 µmol·m-2·s-1) when compared to the sod groundcover (2 µmol·m-2·s-1). This increase on UV reflectance corresponded with an increase in canopy temperature with Extenday®. Maximum daily canopy temperatures were increased by as much as ~ 6 °C. While increased UV light has been associated with the incidence of white drupelet disorder, we did not observe incidence of this disorder.On one of three dates, there was reduced SWD infestation in Extenday plots relative to the control plots. This occurred when SWD infestation levels were relatively low. However, by the 3rd peak harvest date, SWD infestation was severe (~7 larvae per berry) and there were no differences between treatments. Gray mold incidence was not influenced by treatment. In general, most yield and fruit quality parameters were unaffected by ground cover treatment. Vegetative growth of primocanes was influenced by Extenday® when compared to the control. Notably, Extenday® increased lateral branch number (40%), total lateral branch length (53%), and linear bearing surface (38%) of floricane-fruiting blackberry. Since lateral branch development of primocanes is related to bearing capacity and yield in the subsequent year, this response is particularly intriguing. This increase in productive bearing surface may influence yield parameters in 2022. We plan to repeat this study in 2022 using the same plots to determine cumulative effects from this treatment, if present. Optimizing use patterns and timing of deployment will need to be developed if this technology continues to show promise in blackberry production systems.

Tom Kon is an Assistant Professor at North Carolina State University in the Department of Horticultural Science. Tom has a multistate appointment and serves the apple industry in North Carolina, South Carolina, and Georgia. His research and extension program is focused on the development/optimization of cultural and chemical practices to increase orchard productivity and profitability. Additionally, his program has expanded to parallel horticultural research on blackberry. Tom is a Pennsylvania native and received his B.S. from the University of Nebraska, and his M.S. and PhD from Penn State University.

WOULD MY BLUEBERRIES BENEFIT FROM MORE NITROGEN?

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Current Blueberry Nitrogen Recommendations and Practices

The nitrogen (N) fertilization recommendation for established blueberry plants in the Mid-Atlantic region is 65 lbs/acre (1.2 oz/plant) each year. The recommended application timing is to apply half of the N at bloom and the remaining half 6 weeks later. In other regions of the US the N fertilization recommendation for blueberries is higher and recommended applications occur later in the season. For example, in Georgia and Mississippi the recommendation for bearing blueberries grown in soil is 80-120 lbs of N/year, split over 4-5 applications with final applications in July or August. The recommendations for Oregon growers are 100-165 lbs of N/year with applications at bloom, mid-May and mid-June. The vastly different N fertilization rates and application timings in other regions have prompted questions about whether the recommendations for the Mid-Atlantic are high enough and whether a later season N application would be beneficial to blueberry yield.

Blueberry Nitrogen Fertilization Study in Georgetown, Delaware

A blueberry nitrogen rate and timing study was undertaken in an established planting of 'Chandler' northern highbush blueberries at the Carvel Research and Education Center in Georgetown, Delaware. The planting was six years old at the time the study began and yield data was collected over a three year period. Six different rate/timing treatments were tested (Table 1.). Ammonium sulfate was applied to the mulched area, followed by overhead irrigation.

Table 1. Nitrogen Rate and Application Treatments Tested

Lbs of N over # Applications	Application Timing
65 over 2	Bloom, 6 wks post bloom
65 over 3	Bloom, 3 wks and 6 wks post bloom
85 over 2	Bloom, 6 wks post bloom
85 over 3	Bloom, 3 wks and 6 wks post bloom
85 over 4	Bloom, 3 wks, 6 wks and 10 wks post bloom
105 over 5	Bloom, 3 wks, 6 wks, 10 wks, and 14 wks post bloom

Plots consisted of three plants and there were four replications per treatment, resulting in 12 plants that received each nitrogen treatment. Yield was measured on an individual plant basis with harvest twice per week.

Over the three years of the study there were no statistically significant differences in yield between the six nitrogen fertilization treatments (Figure 1). In 2016 a late freeze damaged flowers and reduced yields in all treatments. The highest yields were obtained in 2017 followed by slightly lower yields in 2018.

Additionally, leaf tissue analysis of samples collected from each plot in early August of 2016 and 2017 did not reveal any statistically significant differences in N and all samples were in the sufficient range.

Emmalea Ernest is a Scientist working with the University of Delaware Cooperative 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 a Ph.D. in Plant Science from University of Delaware. She and her husband Jeremy have two daughters.

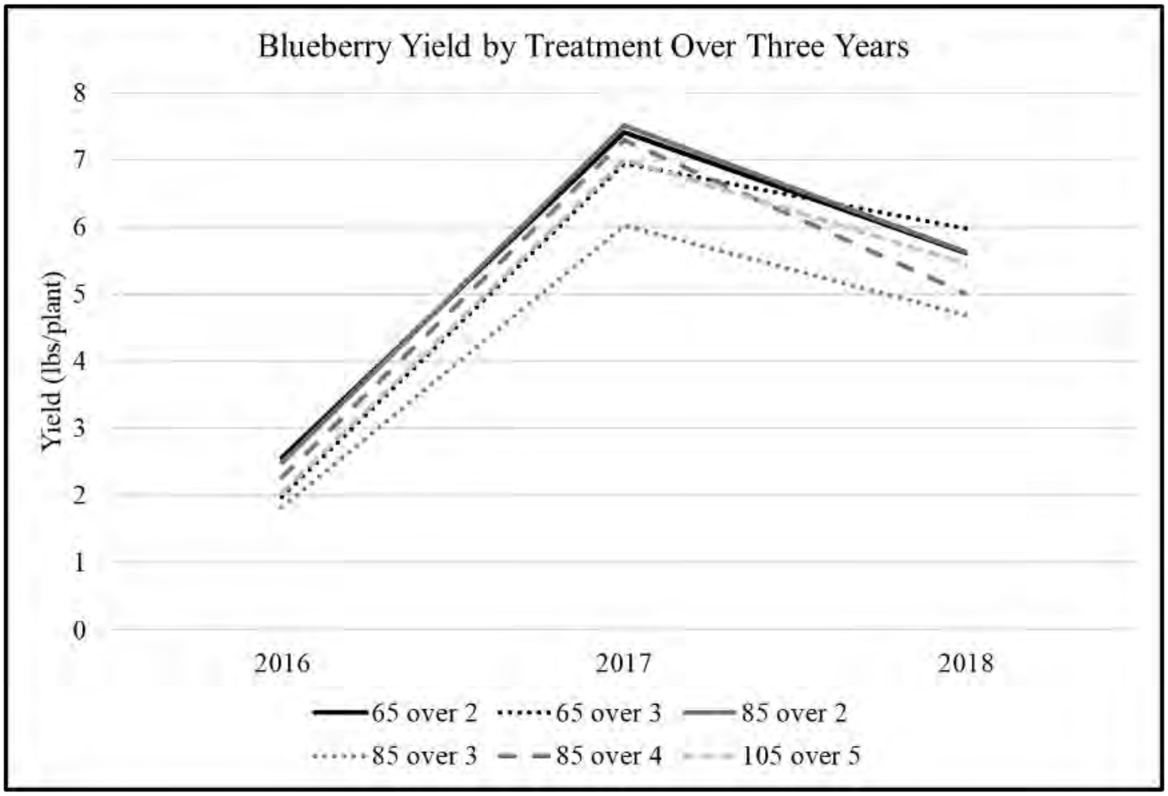

Figure 1. Blueberry yield in pounds/plant for each N fertilization treatment over the three years of the study. There were no statistically significant differences in yield between treatments in any of the three years.

Conclusions

Additional nitrogen, further splitting of nitrogen applications and later season nitrogen applications did not increase yield in Chandler highbush blueberries. Plants that received the current recommendation of 65 lbs/acre of N with half applied at bloom and half six weeks later yielded equivalently to treatments receiving more N, later N applications and more frequent N applications. The current Mid-Atlantic nitrogen recommendation for highbush blueberries provides adequate N, even in the southern part of the region. Mid-Atlantic blueberry growers should use the current N recommendation rate and timing for established plantings.

WILD BEES PROVIDE SUFFICIENT POLLINATION SERVICES TO BLUEBERRY CROPS IN PENNSYLVANIA

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Blueberries are pollination-dependent crops that require sufficient pollen transferred from different varieties to achieve maximum yield (also known as cross-pollination). If flowers do not receive enough pollen grains, fruits may show signs of pollination limitation including low fruit set, smaller than average berries, and late-ripening berries. Pollination limitation may translate into economic losses due to reduced yields and/or fruit marketability. Pollination services to blueberries are provided mostly by wild bees but can be supplemented by managed honey bees. Currently, there is a gap of knowledge about who are the main pollinating insect species of blueberries in Pennsylvania and the degree of pollination limitation of this crop. Here, we provide initial results from a two-year study where we characterized the bee communities and quantified pollination limitation of the Bluecrop cultivar in three farms in central Pennsylvania (Centre and Lycoming counties). We find that wild bees play the most important role in pollination services to blueberries in small diversified farms and that while there are certain signs of pollination limitation in this region, overall there is sufficient pollination provided by the abundant wild bees.

Flower structure and pollination requirements

Blueberry flowers are small and bell-shaped with short anthers hidden inside the corolla and a stigma that is extended near the flower opening (Figure 1A). Pollen grains are contained inside the anthers and require sonication or "buzzing" by bees to be effectively released. Blueberry pollen is sticky and is not easily transported by the wind. Therefore, the most effective pollinators of this crop are bees that can perform buzz pollination, such as bumble bees and other wild bees, while honey bees are not able to buzz pollinate. Honey bees transfer only about 11 pollen grains to the stigma per flower visit compared to 45 pollen grains transferred by wild bees. This means that flowers visited by honey bees need to be visited three times more frequently than flowers visited by wild bees to receive enough pollen for optimum production. While honey bees are still crucial pollinators to commercial blueberry farms, maximum pollination is generally achieved only when wild pollinators such as bumble bees and mining bees visit flowers.

Pollinators of Blueberry

Since Pennsylvania is part of the native range of the blueberry, there is a great diversity of native bees that provide pollination services to blueberry farms. In our observations of the pollinator community at three blueberry farms across central Pennsylvania, pollinator diversity at each site varied, with the smallest planting on a research farm having the greatest diversity of pollinators. Managed honey bee colonies were present at all sites but were comparatively less commonly observed pollinating blueberries (54 visits by honey bees compared to 161 visits by bumble bees in 2021). Mining bees in the genus Andrena were a major pollinator group at all sites (Figure 1B). Six different species within this genus were collected and they were often seen clinging to blueberry flowers during pollination.

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

Figure 1. Blueberry flowers and wild pollinators. (A) Open blueberry flowers with pollen coating their stigmas. (B) A mining bee (Andrena sp.) collecting pollen and nectar from a blueberry flower. Photos by Nash Turley.

Signs and Causes of Poor Pollination

Poor pollination (or pollination limitation) occurs when few pollinators visit flowers, which translates into a low transfer of pollen grains between flowers. Low effective pollination occurs when the number of pollinators (pollinator abundance) is low, or when pollinators are unable to perform the "buzz" needed to shake out pollen. To quantify the ability of Bluecrop to self-pollinate, we bagged flowers to keep out pollinators, which resulted in a 71% reduction in the total number of ripe berries per flower cluster, and a 62% reduction in total harvest weight per flower cluster compared to open-pollinated flowers (Figure 2A). This indicates that for Bluecrop, pollinators are crucial for proper fruit production. Other varieties may be more or less affected by excluding pollinators. To quantify pollen limitation, we hand-pollinated berries to simulate how berries develop under maximum pollination and compared those yields to naturally open-pollinated berries. The number of berries and fruit set obtained by open pollination was not different from those hand-pollinated but there was a 17% decrease in the average weight of each berry in the open-pollinated berries compared to the hand-pollinated berries (Figure 2B). Decreased berry weight is one sign of pollen limitation and indicates initial signs of insufficient pollination at these sites. Low pollinator abundance might be one of the reasons for the slight signs of pollen limitation, reflected by the lower observed berry weight in the branches that were open-pollinated.

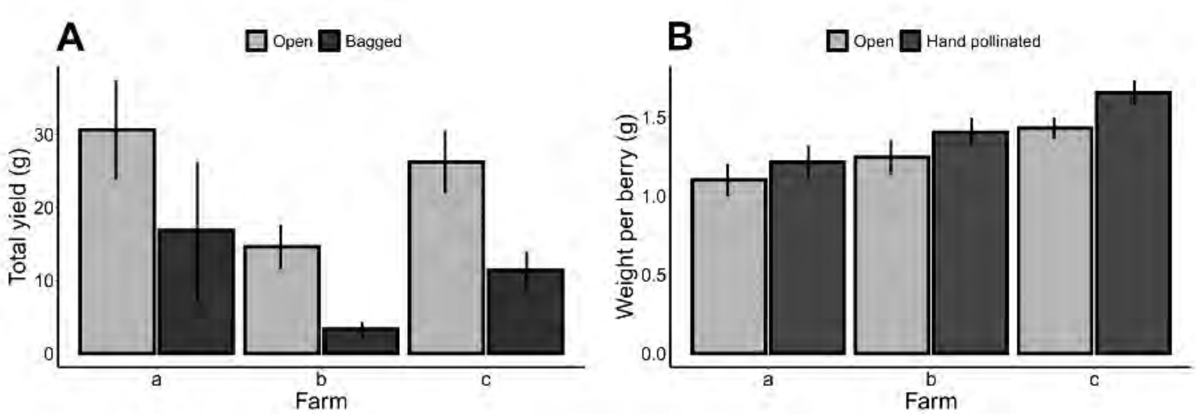

Figure 2. Summary of the results quantifying self-pollination (A) and pollination limitation (B). (A) Ripe berry weight for blueberry branches with no pollination in the bagged treatment (red) compared to open pollination (blue). Lack of pollination visitation leads to a reduction of 71% in berry weight. (B) Hand pollination (pollen addition) treatments resulted in a slight increase in berry weight across three sites in Central PA. Open-pollinated flowers (green) developed into slightly higher-weight berries (an increase of 17% fruit weight) compared to the unaided (open) pollination (blue) flowers.

Recommendations

Growers in Pennsylvania should be aware of the critical importance of wild bees for the production of blueberries, and that in order to reach maximum crop yield, it is necessary to follow best practices to attract and maintain a diverse array of wild pollinators. Many of the native pollinators we observed are ground-nesting bees that need loose exposed soil and prefer undisturbed habitats. Practices that alter the soil, such as tilling, can harm ground-nesting bees. Another practice to promote pollinator diversity includes avoiding highly toxic chemical sprays during bloom. It is also critical to be aware of blooming weeds in row middles and mow them before spraying pesticides. This will discourage the bees from foraging on their flowers when sprays residues are high. The slight indications of pollen limitation of this study of small diversified farms may be amplified at larger blueberry plantings with limited wild bee diversity, so growers may need to supplement pollination by introducing managed honey bees to reduce pollen limitation.

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COMPARING THE PRODUCTION POTENTIAL AND NUTRITIONAL QUALITY OF CONTAINER VS FIELD GROWN BLUEBERRY IN CENTRAL VA

Drs. Reza Rafie and Rafat Siddiqui, Virginia State University, College of Agriculture

Introduction

Blueberry (Vaccinium spp.) is considered an important fruit crop in the United States. The United States is the world's largest producer of blueberries. In 2016, United States, produced and utilized a total of 690 million pounds of cultivated and wild blueberries. The leading top 10 blueberry producing states are Georgia, Michigan, California, Florida, Indiana, Mississippi, New Jersey, North Carolina, Oregon, and Washington. The blueberry production in Virginia is very small and farmers who are growing the crop modify and lower the pH of the soil so it becomes suitable for blueberry production. In recent years, growing blueberry in container, using soilless substrate is becoming a common practice, and farmers are increasingly interested in using this new production system. Blueberries need soil pH of 4.5 to 5.5, and majority of soils in Virginia has high pH, and therefore, not suitable for blueberry production. Container grown blueberry production offers the advantage of not being limited by suboptimal soil conditions in the open field and the ability to control substrate pH, drainage, and organic matter. Also container blueberry production in limited space such as a high tunnel enables moving of plants and adjusting growing density based on plant growth. Soilless substrate with a desirable acidic pH, including composted pine bark, peat moss, and coconut coir, were investigated to serve as possible growing substrates for nursery production of blueberry plants. The concerns of container production include potential constraint on root growth and the unknown feasibility of long-term production. Shallow root systems of blueberries require sufficient irrigation to support plant growth and fruit development. There is a need to investigate the potential of container grown blueberry as a viable commercial production system.

The health benefits of blueberry are well documented. Blueberry is one of the best functional fruits, due to the protective activity of their polyphenol antioxidants, particularly anthocyanin.

In 2021 an experiment was conducted at Virginia State University Research Farm (Randolph Farm) with 6 different blueberry cultivars grown in containers under the high tunnel conditions, and the same cultivars were grown in the field, to compare their yield, fruit size, and fruit nutritional values (antioxidation activities and total polyphenols levels) under the two distinct growing conditions. The blueberry cultivars grown in the field were 6 and 7 years old, and all blueberry cultivars grown in containers in the high tunnels were 3 years old plants. For this experiment, we used two cultivars from the northern highbush type: Duke and Reeka, two cultivars from the southern highbush type:San Jaquan and Suziblue, and two cultivars from the Rabbiteye type: Titan and Ochlocknee (see Table 1). The substrate for the container grown blueberries was 80% shredded pine bark and 20% peat moss.

Table 1. Cultivars within different species of blueberry.

Cultivars	Blueberry					
	Northern Highbush		Southern Highbush		Rabbiteye	
	Duke	Reeka	San Joaquin	Suziblue	Titan	Ochlocknee

Results

Production-Table 2 shows the yield (gram)/plant and the fruit size (gram/fruit) for the six cultivars grown in the field compared with the same cultivars grown in containers in the high tunnels during the 2021 production season. Cultivars Duke, San Joaquin, Suziblue, and Ochlocknee from the field, produced more fruits/plant when compared to the same cultivars grown in containers in the high tunnel. This is not surprising because the field grown blueberry plants were older, and as 6-7 years old plants, they were at the top of their production potential. However, plants for cultivars Reeka and Titan produced more fruits per plant in container in the high tunnel than the same cultivars grown in the field. When comparing the fruit size for cultivars grown in container in the high tunnel, and those grown in the field, there were not significant difference. Cultivar, Titan produced the largest fruit; cultivars, San Joaquin, and Suziblue produced large size fruits; and Ochlocknee and Duke cultivars produced medium size fruits.

Table 2. Yield and fruit size comparison of six different cultivars grown in containers in the high tunnel and in the field.

Cultivar	Yield (gr) for container grown, in tunnel	Yield (gr)-field grown	Fruit size (gr) for container grown, in tunnel	Fruit size (gr) for field grown
Duke	1067	1986	1.6	1.1
Reeka	1855	1010	1.1	1.1
San Joaquin	1681	3153	1.8	1.8
Suziblue	2549	4416	18	1.7
Ochlocknee	2603	3613	1.4	1.4
Titan	1711	139	2.8	2.9

Fruit Nutritional Value Analysis –during the blueberry harvest season in 2021, fruit samples for each cultivar were harvested from the field and from container grown in the high tunnel and were delivered to the Virginia State University Food Chemistry and Nutrition Science laboratory for nutritional analysis. Figure 1 shows the average fruit antioxidation activity for each cultivar grown in the field, and in container in the high tunnel. With the exception of cultivar Duke, there were not significant differences among all cultivars for their antioxidation activities regardless of if they were grown in the field or in containers in the high tunnel. However, Duke cultivar fruits harvested from the field, on the average, had higher level of antioxidation activity when compared with fruit grown in container in the high tunnel. It is important to mention that the Ochlocknee cultivar on the average had the highest antioxidation activity when compared with all other cultivars.

Figure 1: Average total antioxidant activities for six blueberry cultivars grown in the field and in container in in the high tunnel.

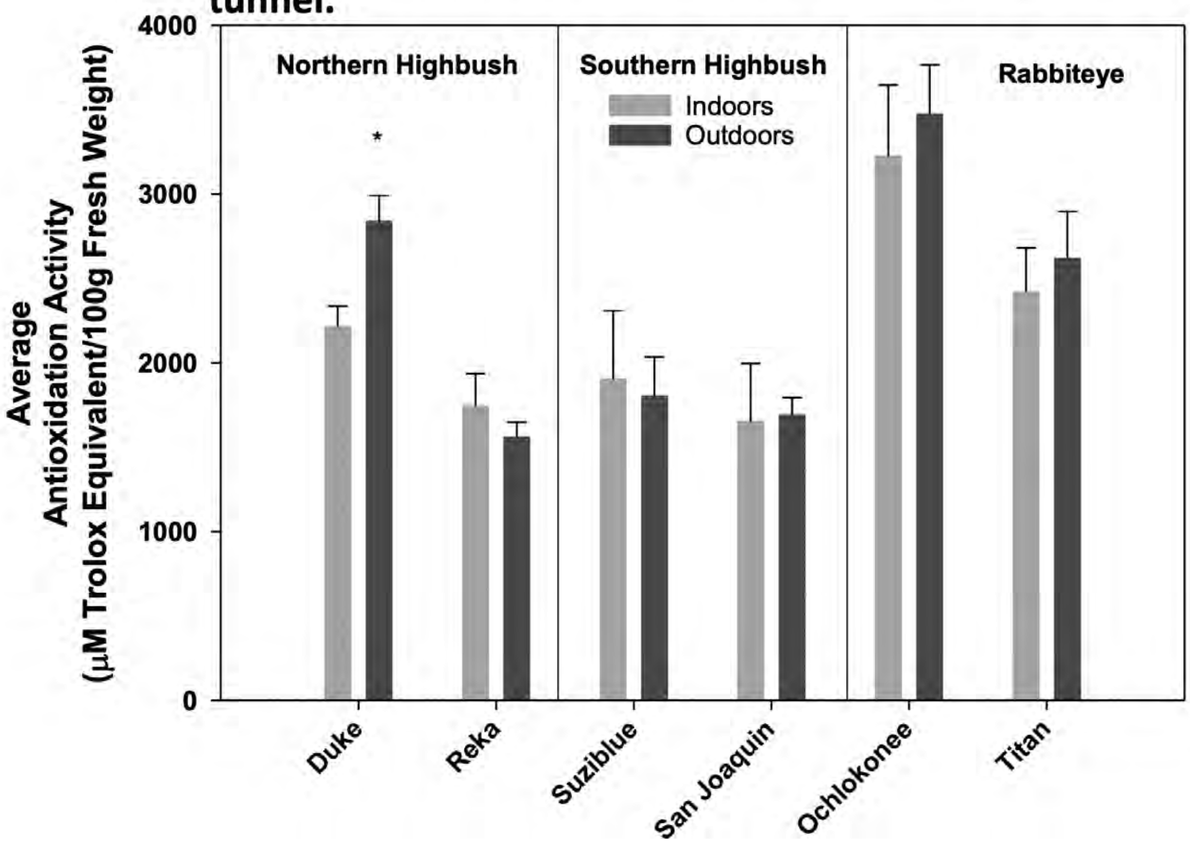
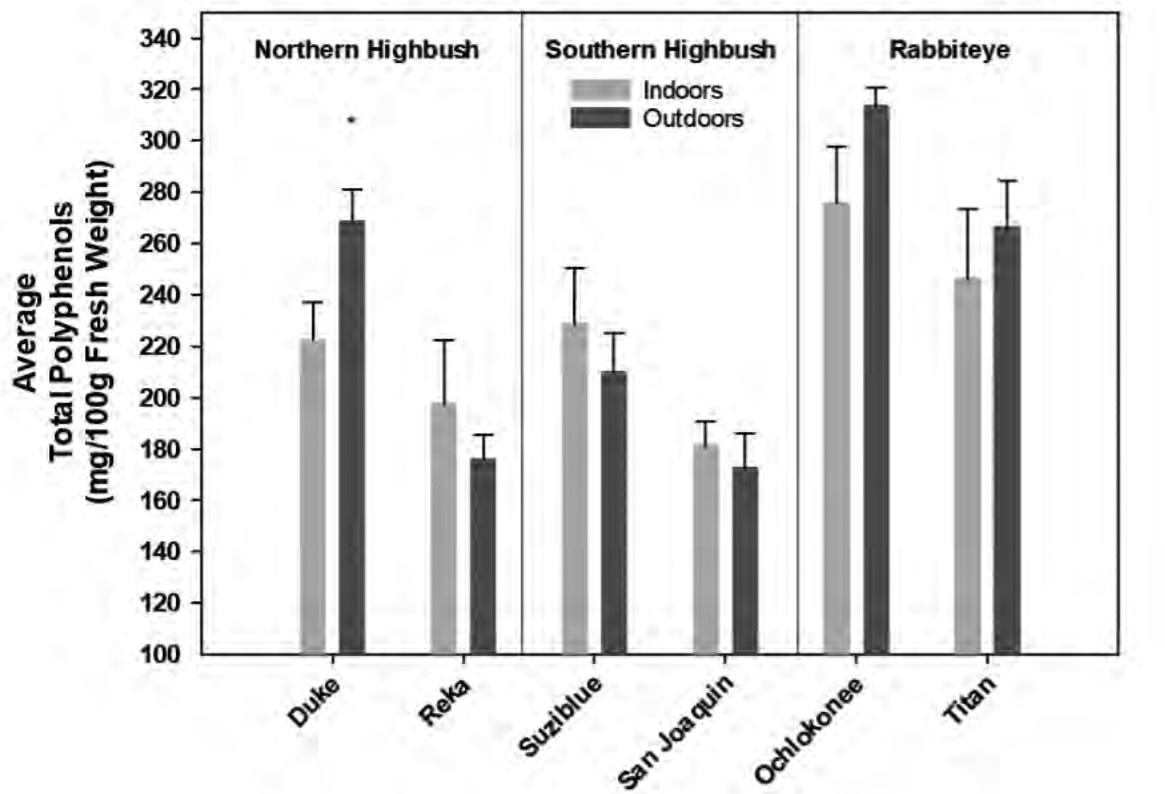


Figure 2 shows the average total fruit polyphenols for each cultivar grown in the field, and in container in the high tunnel. With the exception of Duke cultivar, there were not significant difference for the fruit total polyphenols regardless of whether they were grown in the field or in containers in the high tunnel.. Ochlocknee cultivar had the highest fruit total polyphenols among all other cultivars.

Figure 2. Average total Polyphenols for six blueberry cultivars grown in the field and in container in in the high



Conclusion

Cultivating blueberries in containers from all cultivars, except Duke, has no significant difference in the nutritional values when compared to their cultivation in soil in an open field. Cultivar Duke has higher nutritional values when grown outside. Blueberries cultivars from Rabbiteyes have the highest nutritional values compared to other cultivars.

STRAWBERRY FLOWER MAPPING: THE NITTY-GRITTY OF PREDICTING YOUR YIELDS

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Current recommendations for fall nitrogen application and row cover management in annual strawberry plasticulture are based on tradition and calendar date. Decisions regarding both practices would be more appropriately based on the floral status of plants in production. Pre-plant N normally provided plasticulture strawberries is unnecessary: it does not improve yield. However, targeted weekly pulses of N after floral initiation begins in the fall significantly can enhance subsequent yield. Row covers applied to strawberries in the fall at the appropriate time increase yield the following spring by increasing the number of flowers per plant and protecting plants from excessive cold during dormancy. Many growers fertilize with N and apply row covers based on tradition and calendar date without knowing the floral status of your plants. Flower mapping is used to evaluate a plants floral status. While widely used in Europe, flower mapping has not been developed for US growers and data illustrating its usefulness for North American production has not been generated.

I'll supply you with the science behind this project during this talk and we'll follow it up with a flower mapping workshop to teach you how to do it. Flower mapping is not difficult and you can easily learn the technique and interpret the results to make science-based decisions regarding production practices rather than relying on tradition or calendar date. Flower mapping will be your new management tool and it might even reduce stress associated with these fertilizing and row cover management decisions.

We will supply you with a dissecting kit and teach you how to flower map. Space is limited and tickets for the workshop following this talk will be distributed on a first come, first served basis at the talk prior to the workshop.

If you are interested in trying to flower map but can't attend this presentation, e-mail me at durner@sebs.rutgers.edu for more information.

This work is supported by SARE Project LNE20-395-34268
Empowering Northeastern Strawberry Growers with Flower Mapping

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.

WHAT WE KNOW ABOUT IN-BLOOM PESTICIDE EFFECTS ON HONEY BEES

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Honey Bee Background

The honey bee can be thought of as a "super organism" or colony which is divided into 3 castes: The single queen, the workers (all female) and the drones (males). Workers are divided into the young hive bees (up to 21 days old) that clean cells, keep the brood warm, feed the larvae (brood), produce wax, build the combs, and guard the hive entrance. The older workers (21-45 days old) are the foragers which locate and bring back nectar and pollen. Queens are produced in multiple queen cells in the hive, but only 1 queen will survive to service the colony, and takes 16 days to fully develop. Workers take 21 days to develop from egg to adult, while drones take 24 days to develop.

Honey bees are the most widely used pollination insects in the blueberry industry. They are easily managed, and with communication between the blueberry grower and the beekeeper, colonies can be placed in the fields at optimal timing during the start of blueberry bloom. The conventional wisdom is to place honey bee colonies in a blooming field when 10-20% of the flowers are open. This provides and abundant nectar and pollen source for the newly arrived bees which is thought to discourage the bees from foraging on alternative plants, and to stay in the blueberries. However, blueberry flowers are more likely to set large fruit if they are pollinated within 2-3 days of opening. After this time successful pollination becomes less likely. Depending on the weather and how fast the flowers open, this points to getting bees in the field at closer to 10% bloom. The total northern highbush blueberry pollination period usually lasts between 3 to 4 weeks, depending on the weather and temperature, and the varieties being produced. Therefore it is important to realize that the honey bee colony is trying to produce the equivalent of one entire generation during the pollination period, and expanding its growth at a critical time in the spring. A serious setback during this time can affect colony growth for the entire season.

Blueberry Pests Near and During Bloom

While the bloom is open, blueberry bushes are susceptible to several diseases. These include mummy berry, botrytis fruit rot and anthracnose. Management for mummy berry is usually first focused on the primary phase of the disease shortly before bloom, and botrytis is highly weather dependent, being more common during periods of cool wet weather during the bloom stage. However, anthracnose disease, also known as ripe rot is more likely to infect the developing berries during bloom and fruit set. Overwintering spores on bud scales germinate on newly set (freshly pollinated) fruit. Depending on the variety, bud scales will drop at varying rates during bloom, and a variety like Bluecrop, which holds onto the scales and are slow to drop, is a more susceptible variety to the disease than Duke, which drops its bud scales earlier. This means that the bloom period is a critical time to control anthracnose.

Insect management during this time is largely focused on cranberry weevil about 1 week pre-bloom. During bloom there may be a need to manage gypsy moth, eastern tent caterpillar, spanworms, obliquebanded and redbanded leafroller larvae, as well as cherry fruitworm if numerous. If needed, gypsy moth and tent caterpillar control is usually only required near wooded areas when the larvae 'blow in' from the surrounding trees. Management is required for plum curculio and cranberry fruitworm if present, immediately after bloom as soon as the bees are removed from the fields.

Dean Polk has directed the Rutgers Fruit IPM programs since 1981 and established a blueberry program in 1993. A honey bee health project was started in 2014 to help address the issue of colony decline during blueberry pollination. Chelsea Abegg joined the IPM program in 2016 and is now working on her PhD in entomology and the effects of fungicides on honey bee health.

Given a common pest management picture, both insecticides and fungicides are often used prebloom, followed by 2 to 4 fungicide applications during bloom, and both fungicide and insecticide applications shortly after bloom when the bees are removed.

Maximizing Honey Be Health During Bloom

Honey bee health can be thought of as minimizing the stress factors that the bees encounter. One of those stress factors is the exposure to pesticides. Given the current knowledge about toxicity of pesticides to bees, there are some easy rules to observe to avoid those detrimental effects. Most of this knowledge relates to insecticide toxicity, while new research is starting to also include the effects of fungicides on honey bees. Most insecticides that are used prebloom for weevils and other pests can be highly toxic to bees. These include all the pyrethroids (Asana, Brigade/Bifenture, Danitol, Hero, and Mustang) organophosphates (Imidan, Malathion, and Diazinon), carbamates (Carbaryl and Lannate), Indoxacarb (Avaunt), and most of the neonicotinoids (Actara, Imidacloprid, Platinum). Assail also has limited toxicity to foragers, but research is ongoing for its effect on brood development. In addition, some of the diamides (Exirel and Verdepryn) have been shown to be highly toxic to bees, and Altacor has been shown to be toxic when combined with certain other pesticides. All of these should be avoided during bloom and if used prebloom, then allow at least a 3 day buffer prior to bringing bees into the field. If insecticides need to be used during bloom for various Lepidopteran larvae or 'worms', then a B.t. product such as Dipel or Javelin will work on small worms. Therefor pest scouting is important to catch the presence of larvae in the younger, more susceptible stage. If the larvae are larger, then consider the insect growth regulators (IGRs) Confirm or Intrepid. However, recent research has implicated these IGR materials may have a negative effect on developing brood. The spinosyns (Entrust and Delegate) can also be used on larger larvae, and have shown low bee toxicity when dry, but moderate to high toxicity when wet. Therefor they should only be applied in the evening after foragers have returned to the hives. When insecticides are used shortly after bloom, honey bee colonies should have already been removed and transported at least 3 miles from the field. Removing bees from the field and placing the hives in a nearby holding yard still exposes the bees to insecticides, since some foragers return to the blueberry field, or stop to feed on the extrafloral nectaries present at the base of blueberry leaves.

Recently, fungicide use is starting to get more attention. Recent and ongoing research is pointing to several sub-lethal effects, as well as combination and even some synergistic effects where some fungicides may contribute to honey bee mortality, especially with respect to brood development. Our work and others have shown that a few commonly used fungicides can contribute to larval/brood mortality when exposed at equivalent field rates. In addition, field observations and beekeeper reports have shown an increased queen loss, decreased brood production, and decreased food storage when bees are around intensive fungicide use. These observations have compared hives placed on farms where bees can encounter fresh fungicide sprays several times per week vs hives places on small, isolated farms where the bees may contact fungicide use only once every 10 – 14 days. Colony weights and survival have been better on the small, isolated farms. This seems to be improved when growers spray at night when foragers are not present, and the spray residue is dry in the morning by the time the foragers return.

Honey bee foragers readily collect blueberry nectar, but don't spend a lot of effort collecting the pollen. In fact there is some evidence that blueberry pollen alone is not a well balanced or nutritious food source. Honey bees are opportunistic, and pollen that is returned to the hive in blueberry fields is often a combination of pollen from various sources, including blueberries. Therefore the small farm with surrounding woodlands may also be providing a more nutritious diet as well as reduced pesticide exposure. While pesticides and an unbalanced diet can contribute to hive stress factors, other stress factors can include over-crowding and varroa mite load. If possible, beekeepers should be supplying as near a mite free hive as possible. Standard pollination recommendations have been to suggest 2+ hives per acre with each hive consisting of 8-10 frames of brood in all stages of development in a double deep box arrangement, often with a honey super on top. These hives are often migratory, and have recently arrived from Florida or California, already stressed from the trip. With an abundant food source a full hive can easily swarm into 2 smaller or weaker colonies. The weaker colony that remains in the box may now more negatively respond to pesticide and varroa stresses.

In summary:

1) Colonies should be placed in the field at close to 10% bloom.
2) At least a 3 day buffer should be allowed between the last prebloom insecticide and bloom or the arrival of honey bee colonies.
3) All bee toxic insecticides should be avoided during bloom, and pest scouting used to catch any young insect population that needs to be treated.
4) Hives should be removed immediately at the end of bloom and relocated at least 3 miles from the blueberry fields.
5) Make the first anthracnose fungicide application immediately before bringing bees in instead of just after they arrive.
6) Avoid the direct contact of fungicides and other freshly applied pesticides with foragers and hives by spraying in the evening after foragers have returned to the hive, and avoiding any over-spraying of the hives.
7) Do not mix pesticide types if possible. This decreases the likelihood of phytotoxic effects on the plant and can minimize the possibility toxic effect on the bees.

Acknowledgements. This work has been funded through USDA SARE grants LNE18-364-32231 and GNE20-226-34268, Project Apis m., NJ Beekeepers Association, and the NJ Blueberry Industry.

NEW TOOLS FOR MONITORING FOR SWD

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Background

Spotted-wing drosophila (SWD), Drosophila suzukii Matsumura (Figure 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. SWD has since established in many states across the country; it first 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.

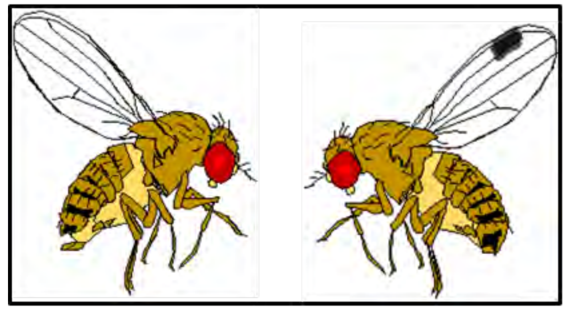

Figure 1. Female (left) and male (right) SWD. Males have a distinctive black spot on each wing near the tip. (Drawing by K. Cloonan).

SWD Monitoring

Early detection of SWD flies is necessary for growers to time insecticide applications and prevent fruit infestation. Traps used for monitoring should be placed in the field at least two weeks before fruit ripening and should be monitored weekly. Traps should be placed at bush level close to the developing fruit, preferably along the edges of the field that have wooded borders.

Figure 2. Trap types: liquid (standard) trap (A) and dry, red-panel sticky trap (B).

So far, monitoring tools for SWD flies have mostly relied on liquid traps (Figure 2A), baited with a lure. Traps may be purchased or simply made by hand and involve cutting two round holes on both sides of the upper portion of a clear 32 oz. deli cup, a piece of mesh material is then glued in place over those holes, and a lure can be hung from the lid over a solution of apple cider vinegar with a drop of scentless soap. There are two commercial SWD lures available for purchase: Trécé and Scentry SWD lures. The trap solution is inspected for SWD males and females.

However, processing these liquid traps, i.e., counting the number of captured flies, can be time consuming and labor intensive. To mitigate this, we have been testing alternative trapping designs that can be processed quickly and on-site.

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.

2018 Trials

In 2018, studies were conducted in New Jersey to compare the efficacy of two different trap types, a standard, liquid trap baited with the Scentry lure (Figure 2A) and a dry red-panel sticky trap baited with the Scentry lure (Figure 2B), on SWD captures.

This study was conducted in five blueberry fields in New Jersey that were either organic or not sprayed for SWD. Four treatments were compared: A) a liquid (standard) trap (see above) baited with a Scentry lure, B) a dry, red-panel sticky, trap baited with a Scentry lure, C) an unbaited liquid trap, and D) an unbaited dry, red-panel sticky trap. Traps were placed at least 10 m from each other and checked weekly for SWD males and females for seven weeks from 13 June-25 July 2018. In addition, fruit was collected weekly to assess fruit infestation.

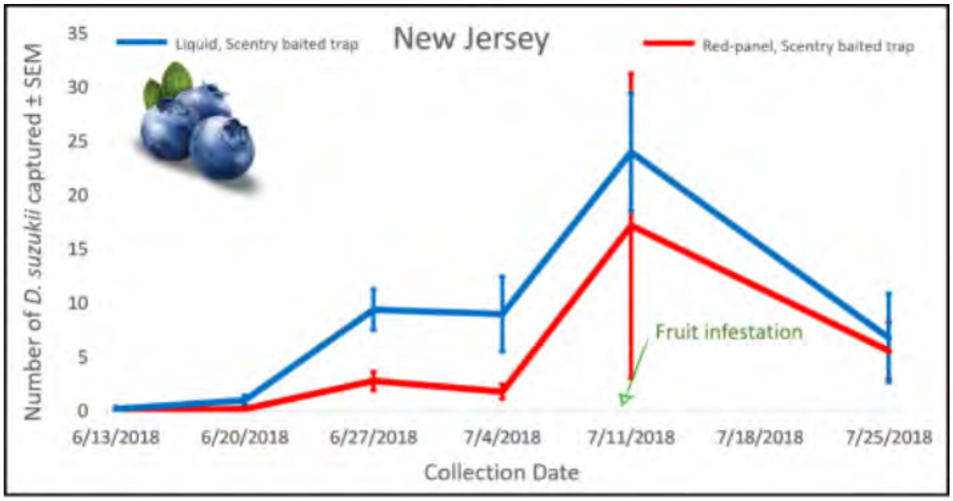

Figure 3. Efficacy of a liquid (standard) trap and a dry, red-panel sticky trap for monitoring SWD flies in blueberries in New Jersey. Both traps were baited with a Scentry lure.

Results show that SWD first catch in the liquid baited trap was on 13 June and first catch in the red-panel baited trap was one week after, on 20 June (Figure 3). No flies were captured in either control trap type. Both trap types captured similar numbers of SWD males and females. Fruit infestation was first detected on 27 June.

2021 Trials

In 2021, studies were conducted in commercial blueberry farms in New Jersey to test the efficacy of red-panel sticky traps either baited with a Scentry lure (broad spectrum), a Trécé lure (broad spectrum), or none. Only adult males were monitored on the traps. Traps were placed on field edges by woods borders and checked every 7 days from June through August.

SWD fly counts on sticky traps increased throughout the growing season and there was no differences between the two lures (Figure 4).

In summary, first captures of SWD were either on the same week or one week later between Scentry-baited red sticky traps and the standard liquid trap. Both traps detected SWD before infested fruit was first detected, indicating that they can provide early warning. Both commercial Scentry and Trécé lures were effective at capturing SWD on sticky traps. Therefore, dry, red-sticky traps can be used for rapid detection of SWD males in the field. However, their performance will likely depend on the crop and regional growing conditions.

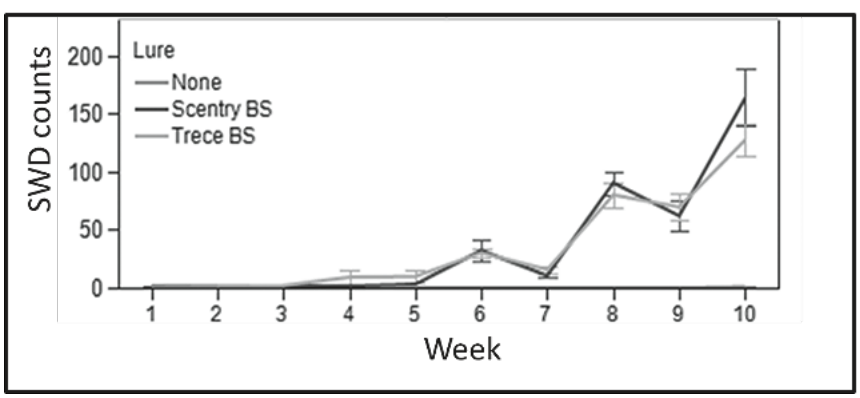

Figure 4. Efficacy of red-panel sticky traps either baited with a Scentry lure (broad spectrum), a Trécé lure (broad spectrum), or none for monitoring SWD flies in blueberries in New Jersey.

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TIP TALK: EVERYTHING TO KNOW ABOUT SPRAY NOZZLES

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Welcome to my Tip Talk!

Nozzles are an essential, yet often overlooked tool to the pesticide application process. Pesticide performance is directly related to nozzle quality and nozzle selection. Nozzles control the flow rate of the pesticide product, form the pesticide product into droplets, and disperse these droplets into specific spray patterns.

Understanding the letters and numbers on the spray nozzle is necessary to choose the correct nozzles for the job. Nozzles typically have the same information on the tip regardless of brand. This information includes the brand name, an abbreviation for the type of nozzle, the spray angle, an output rating in gallons per minute (GPM) at 40 PSI, and what material the nozzle is made from.

- Common nozzle type abbreviations include XR extended range, AI air induction, DG drift guard, and when no abbreviation is present it is a standard flat fan nozzle.
- Spray angles range from 65 to 110 degree with the most common being 80 and 110 degrees. The wider the spray angle the closer to the target the spray boom can be while still achieving adequate coverage.
- The output rating in GPM at 40 PSI is an industry standard. This number helps the applicator calculate the output across the whole spray boom.
- The material of the nozzle will determine the cost and lifespan of the nozzle. Brass and polymer are cheaper but wear quickly and do not have a long lifespan. Stainless steel or ceramic are more expensive but resist wear and have a longer lifespan.

Nozzle quality is directly related to nozzle output and spray pattern. Worn nozzles have a higher output and less uniform spray pattern. Nozzles are one of the most critical items to a proper pesticide application and yet they are one of the most neglected. Take the time and check your tips!

Kara Pittman is an Extension Educator with the Pesticide Education Program at Penn State. She is involved in education and outreach efforts for pesticide applicator certification and recertification. She received a Bachelor of Science degree in Horticultural Science from NC State University and a Master of Science in Life Sciences, with a focus in Weed Management, from Virginia Tech. Prior to working with the Pesticide Education Program, Kara worked as a Research Associate in the Crop and Forage Weed Management Lab at Virginia Tech.

RISK MANAGEMENT CONSIDERATIONS FOR HORTICULTURAL CSROP GROWERS

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When considering profitability, many people outside of the horticulture industry are often seduced by the potential of fruit and vegetable production. Compared to most agronomic crops, horticultural crops offer the opportunity to produce a fair amount of income on a small acreage. However, as a fruit or vegetable grower you understand that with this income potential come sizable risks. These risks can be categorized as either those which impact on receipts or those which relate to the cost of production.

Yield and Price Risk. Receipts are the gross returns (price times yield) from production. Variability in both yield and prices will affect your receipts. Your ability to deal with both types of variability will impact the profitability of the enterprise. Large yields are generally not the most important yardstick; having sufficient sales of high-quality produce is the key to profitability. Poor quality produce results in both lower prices and less produce to sell because it does not meet your buyer's standards for quality. For most perennial horticultural crops (tree fruits and nuts, small fruits), overall profitability is complicated by the fact that receipts are zero for several years while the planting is in the pre-productive stage.

Every year you face yield risk in the form of adverse weather and pest damage. In a perennial crop like tree fruit, this yield risk can take the form of year-to-year variability or more serious damage which reduces the long-term production potential of the planting. In extreme cases such as severe winters, or with wind damage, trees and vines can be lost and need to be replanted. Although yield risk is important, it usually has readily identifiable causes and remedies. In the Northeast, for example, the quantity and distribution of rainfall does not match the amounts required for optimal performance of fruit and vegetable crops, and seasons in which moisture is a severe limiting factor affecting profitability occur perhaps two or three years in 10 for individual growers. You can reduce the effects of yield risk through irrigation (see Lamont et al., 2001, 2012), pest management practices, and site and cultivar selection. Planting on well-drained soils and on sites with adequate air drainage can reduce your yield risk considerably.

Jayson K. Harper, Professor of Agricultural Economics, has been at Penn State University since 1989 and has served as the Director of the Fruit Research and Extension Center since 2019. His extension and research interests focus on risk management and crop production economics. Work on horticultural crops has included crop insurance, cost of production, alternative apple and peach production systems, high tunnel production systems, irrigation, mechanical harvesters, hydroponic vegetable production, processing apple quality factors, evaluation of vegetable production systems, tree fruit IPM, and assessing the economic impact of invasive species including plum pox virus, brown marmorated stink bug, and spotted lanternfly. Work on agronomic crops has included evaluation of crop insurance options, cost of production, crop rotations, herbicide selection criteria, conservation tillage systems, machinery sizing and replacement, and crop harvest and storage systems. He has led the Penn State Small and Part-time Farming Project since 1992, which includes the 69 publications in the Agricultural Alternatives series.
Dr. Harper has extensive international experience including work in Australia, New Zealand, Mexico, Poland, Ukraine, Serbia, Russia, and Kazakhstan. In 1997 he had a sabbatical at the University of Queensland in Brisbane, Australia where he did research on integrated pest management for tropical crops. In 2005 he had a sabbatical at Massey University in Palmerston North, New Zealand where he did research on high-density apple production systems and orchard replacement economics. During 2013-14 he had a sabbatical split between Cornell University in Geneva, NY and the University of Puerto Rico in Mayaguez. Dr. Harper received his B.A. in economics and business from the University of Northern Colorado in 1981, his M.S. in agricultural economics from the University of Arkansas in 1983, and his Ph.D. in agricultural economics from Texas A&M University in 1988.

Marketing Risk. While it is important to minimize the effect of yield risks and its impact on profitability, horticultural crop growers are usually much more equipped to deal with this type of risk than those associated with marketing. Marketing plays a crucial role in the profitability of horticultural crop production and must be planned well in advance of harvest. In fact, you should be thinking of marketing prior to the growing season. This is particularly important for perennial crops where decisions about which varieties to plant are made several years prior to the first crop.

Knowledge of what the market requires (in terms of form and quality) and when is the key to success. Why do growers on good sites sometimes go out of business, while others in less ideal production circumstances thrive? Often the difference is keen marketing insight. Developing a marketing strategy requires careful evaluation of the supply and demand for your product and investigation of market alternatives. Successful marketers strive to produce products which satisfy basic customer needs and wants rather than simply selling products it produces. Strategic marketing planning requires specification of target markets, or the individuals or businesses that you have identified as your most desirable customers. Identifying your target market in turn drives decisions about products (including varieties and packaging), promotion, pricing, location, and distribution strategies.

Seven traditional (distribution) alternatives are generally available to horticultural growers: wholesale market, marketing cooperatives, local retail, roadside stands, farmers markets, pick-your-own, and processing. Other options such as rent-a-row/tree, community supported agriculture, and internet and/or mail order may be worth investigating depending on the nature of your farming operation, the population and demographics in your area (i.e., market potential), and the crops grown.

Wholesale marketing is often done on a producer assignment basis, where shippers market and ship the fruit for a predetermined rate. Regardless of whether a shipper is used to take the crop to a wholesale market, or it is done by the individual, this marketing alternative is typically subject to the greatest price fluctuations. Marketing cooperatives generally use a daily pooled cost and price, which spreads price fluctuations over all participating growers.

Local retail (selling directly to grocery stores) is another possibility, but considerable time must be spent in contacting produce managers and providing consistent quality when the store requires the produce. Roadside stands (either your own or another growers), pick-your-own operations, and farmers markets are other marketing options. Although they provide an opportunity for you to receive higher than wholesale prices for your produce, there will be significant expenses for advertising, trucking, building and maintaining a facility, and employing people to service customers. In a pick-your-own (PYO) operation, harvest costs are saved, but you must also be willing to accept some wastage. Furthermore, if you direct market you should understand that greater legal risk is faced when dealing with consumers directly. The risk of food contamination, injuries (especially for PYO operations), and other potential liability claims significantly increase the cost of insurance for many direct marketers. More information on operating roadside stands and direct marketing can be found in Dunn et al. (2006).

Depending on location, processing may or may not be a marketing option. Processing prices are often much more volatile than fresh-market prices. However, processing cooperatives, such as Knouse Foods, National Grape Cooperative (Welch's), and Ocean Spray are examples of cooperatives in the Northeast whose marketing practices seek to reduce cash flow variability for their members. For more information on markets and marketing alternatives, see Dunn, Harper, and Kime (2009).

Organic production may be an alternative that could provide you with a marketing niche. However, the cost of certification and the time and labor involved in managing the system are high. Growing organically is not for everyone since it requires detailed record keeping and more management and planning than other production systems. Quality organic production is also challenging given the Northeast's climate with relatively high rainfall and humidity. More information on the organic certification process, system plans, and production practices (including plant selection, soil fertility, pest management, and crop selection) can be found in Sánchez, et al. (2014).

Price and quality are synonymous in horticultural crop production. Unfortunately, it is not always clear what is meant by "high quality" and quality judgments can vary from person to person and from year to year. Federal grade standards do not exist for all horticultural crops and established standards are often not very specific. Often there is only one recognized quality grade, U.S. No. 1, which means produce of "good average quality". Buyers, however, often have additional criteria by which they judge produce quality including flavor, ripeness, aroma, cleanliness, and the absence of pest damage and foreign material.

Proper disease management, harvest practices (including picker instruction and supervision), and post-harvest handling are critical to marketing success. Cooling produce to remove field heat and improve shelf life is especially important. Treatments to reduce decay may be another important consideration. Sorting and washing of some fruits and vegetables can also be done to help maintain quality and improve appearance. For certain crops like small fruits and other delicate produce, sorting and/or washing is not an option; harvest crews must be well-trained, and quality continuously monitored to assure a marketable crop.

Using Insurance to Manage Risk. There may be multi-peril crop insurance (MCPI) programs available to help you manage risk to your horticultural enterprises. MPCI is available for many fruit and vegetable crops grown in the Northeast including apples, grapes, cabbage, snap beans (canning and processing), cranberries, peaches, pears, peas, peppers, plums, potatoes, stone fruit, sweet corn (canning and freezing, and fresh market), and tomatoes (canning and processing, and fresh market). Because individual crop insurance coverage is not available for all crops, you may want to consider using the Whole Farm Revenue Protection (WFRP) program to insure the revenue of your entire farm operation. Information from your Schedule F tax records (or a "Substitute Schedule F for WFRP Purposes" if you do not file a Schedule F) from the past five consecutive years is used to calculate the WFRP policy's approved revenue guarantee. Operations that have expanded over time may be allowed to increase the approved revenue amount based on an indexing procedure. Organic producers can now use the expansion option to increase to the higher of $500,000 or 35 percent (USDA-RMA, 2021). Depending on the number of commodities grown, you have the choice of coverage of 50 to 85 percent of your approved revenue. Coverage and premium costs depend on the level of diversification in your operation; the maximum level of insured revenue is $8.5 million (based on maximum adjusted gross revenues of $17 million and the 50 percent coverage level). WFRP also provides replant coverage if it not already covered under an underlying individual crop policy.

In addition, USDA Farm Service Agency has a program called the Noninsured Assistance Program (NAP) that is designed to provide a minimal level of yield risk protection for producers of commercial agricultural products that don't have multi-peril crop insurance coverage. NAP is designed to reduce financial losses when natural disasters cause catastrophic reduction in production. A basic level of coverage (50 percent of expected production at 55 percent of the average market price) is available for a fee of $325 per crop per county (fees are capped at $825 per producer per county, but not to exceed a total of $1,950 for producers growing crops in multiple counties). Higher levels of protection at the 50, 55, 60, and 65 percent levels at 100 percent of the average market price are available for additional premium. NAP coverage is available through your local USDA Farm Service Agency office. The application fee for this program may be waived for eligible limited-resource farmers.

Finally, you should make sure that you have sufficient insurance coverage for liability and damage to your farm's facilities and equipment. This may be accomplished by consulting your insurance agent or broker. You will also need workers compensation insurance if you have any employees. You may also want to consider your needs for life and health insurance and if you need coverage for business interruption or employee dishonesty. For more on agricultural business insurance, see Kime et al. (2019).

Cost of Production. Horticultural crop production is not for the financially faint of heart. For certain vegetable crops, preharvest costs may amount to several thousand dollars per acre. For perennial crops, substantial initial investments are required and several years may go by before the first dollar returns to the operation. Depending on the perennial crop, the pre-productive costs for land preparation and establishment can range from $2,000-$20,000 per acre. This is the period where you are most exposed to financial risk. You need to realistically assess your ability to absorb losses during this period and not rely on single enterprises for current and future income. For more information on financing options and financial risk management see Stokes et al. (2005).

Naturally, growers are concerned when the cost of fertilizers and pesticides increase. Recent increases in the cost of fertilizers, pesticides, and fuel make the current production environment very challenging. Some are even tempted to reduce these costs by cutting applications. In the whole scheme of things, however, these costs are relatively minor. It makes little economic sense to jeopardize your overall profitability and reputation as a reliable producer by trying to save a few dollars here and there. Once the crop is established, the major cost by far in horticultural crops is for harvesting and marketing. Labor management and costs should be one of your primary concerns because labor often makes up 40 to 60 percent of total costs. Investing in production practices which reduce your yield and quality variability are rarely a waste of money.

Good labor management is a key to horticultural crop profitability. Because of the perishable nature these products, hand picking is usually the only alternative. Understanding the labor market and planning for adequate and experienced labor is critical to having a high-quality crop ready for market. Communicating your firm's personnel policies is a key element in effective human resource management. You must understand the federal, state, and local laws which apply to the use of agricultural labor. These laws include those relating to migrant and seasonal workers, immigration, child labor, wages and hours, withholding taxes, unemployment compensation, family and medical leave, worker's compensation, worker protection (pesticide exposure, safe workplace, field sanitation), and migrant housing (more information on the state and federal laws that apply to farm labor can be found in Part IX of Penn State's Tree Fruit Production Guide).

Horticultural crop budgeting. Understanding the magnitude of the financial risks and the nature of cash flows in horticultural crop production requires the preparation of enterprise budgets. Enterprise budgets represent estimates of the receipts (income), costs, and profitability associated with the production of agricultural products. Budgets are used to:

- enumerate the receipts (income) received for an enterprise
- account for the cost of inputs and production practices required by an enterprise
- evaluate the efficiency of farm enterprises
- estimate benefits and costs for major changes in production practices
- provide the basis for a total farm plan
- estimate break-even price and/or yield for market planning purposes
- support applications for credit

Enterprise budgets should contain receipts (income) for every product and by-product of the enterprise. Prices should be used which reflect the markets you service, and the productivity of the enterprise given your specific resource situation (land, labor, equipment, etc.).

Enterprise budgets contain several cost components. Determining the costs of various decisions can be difficult. Frequently, individuals disagree over which costs to include and how they should be measured. Understandably, these differences arise because production costs are unique to each individual resource situation.

One of the more common classifications divides costs into variable and fixed costs. Variable costs are those expenses that vary with output within a production period. Examples include fertilizer, chemicals, fuel, repairs, hourly or seasonal labor, and marketing. Other terms used to describe variable costs include cash costs (or expenses), direct costs, and out-of-pocket costs.

Fixed costs include depreciation, taxes, interest on investment, land charges, annual labor, and insurance. Sometimes, a management fee is also included as a fixed cost. These costs are considered to be "fixed" because they generally remain at the same level within a production period and do not vary with the level of output. Indirect, non-cash, and overhead costs are other terms used to describe fixed costs. Land can either be a variable cost (if you rent it) or fixed cost (if you own it).

Total costs are the sum of variable and fixed costs. Although your aim is to earn a return above total costs (profit), this is not always possible. Because of yield or marketing conditions beyond your control, income received is sometimes less than the total costs of production. Should you continue to grow the crops under these circumstances? The answer may be yes if: (1) returns are above variable costs and (2) it is a short-term condition. If your fixed costs are not covered in the long run, however, reinvestment in capital items (like tractors, implements, buildings, and equipment) is difficult and often the result is a depletion of the existing capital stock.

More information on the use of crop budgeting for farm management decision making can be found in Harper et al. (2019). To help in the evaluation of horticultural crops for small-scale or part-time farmers, Agricultural Alternates leaflets have been developed by Penn State Extension which include cost of production and marketing information for apple, asparagus, blueberries (highbush), broccoli, cantaloupes, cucumbers, cut flowers, garlic, grapes, hops, onions, peaches, peppers, potatoes, pumpkins, raspberries, snap beans, strawberries, sweet corn, table grapes, tomatoes, watermelons, and wine grapes (available on-line at http://extension.psu.edu). Budgets on tree fruits (apples, peaches, tart cherries, and sweet cherries) can be found in Harper and Kime (2021).

Conclusions. Horticultural crop production has better than average profit potential and the ability to generate considerable income on a smaller land base. This profit potential, however, comes with a high amount of risk. You must be prepared to not only produce a high-quality crop, but also be an active and aggressive marketer. Initial investment costs can be very high and substantial annual cost of production requires you to be able to financially weather annual cash flow demands (and the costs associated with pre-productive years in perennial crops). If you can balance the demands of production and marketing, the future of fresh-market horticultural crop production appears quite favorable. Per capita fresh consumption of most fruits and vegetables are stable or growing and with population growth this bodes well for the continued strength of fresh market prices.

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FACT SHEET #26: SECTION H-2A OF THE IMMIGRATION AND NATIONALITY ACT (INA)

Luis Nieves, Jr., US Dept. of Labor

This fact sheet provides general information concerning the application of the H-2A requirements to the agricultural industry for H-2A applications submitted on or after March 15, 2010.

Introduction

The Immigration and Nationality Act (INA) authorizes the lawful admission of temporary, nonimmigrant workers (H-2A workers) to perform agricultural labor or services of a temporary or seasonal nature. The Department of Labor's regulations governing the H-2A Program also apply to the employment of U.S. workers by an employer of H-2A workers in any work included in the ETAapproved job order or in any agricultural work performed by the H-2A workers during the period of the job order. Such U.S. workers are engaged in corresponding employment.

Overview of Employer Contractual Obligations

Recruitment of U.S. Workers : In order for the Department of Labor to certify that there are not sufficient U.S. workers qualified and available to perform the labor involved in the petition and that the employment of the foreign worker will not have an adverse effect on the wages and working conditions of similarly employed U.S. workers, employers must demonstrate the need for a specific number of H2A workers. In addition to contacting certain former U.S. employees and coordinating recruitment activities through the appropriate State Workforce Agency, employers are required to engage in positive recruitment of U.S. workers. H-2A employers must provide employment to any qualified, eligible U.S. worker who applies for the job opportunity until 50 percent of the period of the work contract has elapsed. Employers must offer U.S. workers terms and working conditions which are not less favorable than those offered to H-2A workers.

Termination of Workers : Employers are prohibited from hiring H-2A workers if the employer laid off U.S. workers within 60 days of the date of need, unless the laid-off U.S. workers were offered and rejected the agricultural job opportunities for which the H-2A workers were sought. A layoff of U.S. workers in corresponding employment is permissible only if all H-2A workers are laid off first. Employers may only reject eligible U.S. workers for lawful, job-related reasons.

In order to negate a continuing liability for wages and benefits for a worker who is terminated or voluntarily abandons the position, employers are required to notify the Department of Labor (DOL), and in the case of an H-2A worker the Department of Homeland Security, no later than two working days after the termination or abandonment.

Rates of Pay : The employer must pay all covered workers at least the highest of the following applicable wage rates in effect at the time work is performed: the adverse effect wage rate (AEWR), the FS 26 applicable prevailing wage, the agreed-upon collective bargaining rate, or the Federal or State statutory minimum wage.

Wages may be calculated on the basis of hourly or "piece" rates of pay. The piece rate must be no less than the piece rate prevailing for the activity in the area of intended employment and on a pay period basis must average no less than the highest required hourly wage rate.

Written Disclosure: No later than the time at which an H-2A worker applies for a visa and no later than on the first (1st) day of work for workers in corresponding employment, the employer must provide each worker a copy of the work contract – in a language understood by the worker – which describes the terms and conditions of employment. In the absence of a separate written work contract, the employer must provide each worker with a copy of the job order that was submitted to and approved by DOL. The work contract must include:

- the beginning and ending dates of the contract period as well as the location(s) of work;
- any and all significant conditions of employment, including payment for transportation expenses incurred, housing and meals to be provided (and related charges), specific days workers are not required to work (i.e., Sabbath, Federal holidays);
- the hours per day and the days per week each worker will be expected to work;
- the crop(s) to be worked and/or each job to be performed;
- the applicable rate(s) for each crop/job;
- that any required tools, supplies, and equipment will be provided at no charge;
- that workers' compensation insurance will be provided at no charge; and
- any deductions not otherwise required by law. All deductions must be reasonable. Any deduction not specified is not permissible.

Guarantees to All Workers: H-2A employers must guarantee to offer each covered worker employment for a total number of hours equal to at least 75% of the workdays in the contract period – called the "three-fourths guarantee." For example, if a contract is for a 10-week period, during which a normal workweek is specified as 6 days a week, 8 hours per day, the worker would need to be guaranteed employment for at least 360 hours (e.g., 10 weeks x 48 hours/ week = 480 hours x 75% = 360).

If during the total work contract period the employer does not offer sufficient workdays to the H-2A or corresponding workers to reach the total amount required to meet the three-fourths guarantee, the employer must pay such workers the amount they would have earned had they actually worked for the guaranteed number of workdays. Wages for the guaranteed 75% period will be calculated at no less than the rate stated in the work contract.

Housing: Employers must provide housing at no cost to H-2A workers and to workers in corresponding employment who are not reasonably able to return to their residence within the same day. If the employer elects to secure rental (public) accommodations for such workers, the employer is required to pay all housing-related charges directly to the housing's management.

In addition, employers are required to either provide each covered worker with three meals per day, at no more than a DOL-specified cost, or to furnish free and convenient cooking and kitchen facilities where workers can prepare their own meals.

Employer-provided or secured housing must meet all applicable safety standards.

Transportation: Employers must provide daily transportation between the workers' living quarters and the employer's worksite at no cost to covered workers living in employer-provided housing. Employerprovided transportation must meet all applicable safety standards, be properly insured, and be operated by licensed drivers.

Inbound & Outbound Expenses: If not previously advanced or otherwise provided, the employer must reimburse workers for reasonable costs incurred for inbound transportation and subsistence costs once the worker completes 50% of the work contract period. Note: the FLSA applies independently of H-2A and prohibits covered employees from incurring costs that are primarily for the benefit of the employer if such costs take the employee's wages below the FLSA minimum wage. Upon completion of the work contract, the employer must either provide or pay for the covered worker's return transportation and daily subsistence.

Records Required: Employers must keep accurate records of the number of hours of work offered each day by the employer and the hours actually worked each day by the worker.

On or before each payday (which must be at least twice monthly), each worker must be given an hours and earnings statement showing hours offered, hours actually worked, hourly rate and/or piece rate of pay, and if piece rates are used, the units produced daily. The hours and earnings statement must also indicate total earnings for the pay period and all deductions from wages.

Additional Assurances and Obligations: Employers must comply with all applicable laws and regulations, including the prohibition against holding or confiscating workers' passports or other immigration documents. In addition, employers must not seek or receive payment of any kind from workers for anything related to obtaining the H-2A labor certification, including the employer's attorney or agent fees, the application fees, or the recruitment costs. Employers must also assure that there is no strike or lockout in the course of a labor dispute at the worksite for the H-2A certification which the employer is seeking. In addition, employers cannot discriminate against – or discharge without just cause – any person who has filed a complaint, consulted with an attorney or an employee of a legal assistance program, testified, or in any manner, exercised or asserted on behalf of himself/herself or others any right or protection afforded by sec. 218 of the INA or the H-2A regulations.

H-2A Labor Contractors

An H-2ALC is a person who meets the definition of an "employer" under the H-2A Program and does not otherwise qualify as a fixed-site employer or an agricultural association (or an employee of a fixedsite employer or agricultural association) and who is engaged in any one of the following activities in regards to any worker subject to the H-2A regulations: recruiting, soliciting, hiring, employing, furnishing, housing, or transporting.

While H-2A does not require labor contractors to register as such with the Department, any person who is subject to MSPA as a Farm Labor Contractor (FLC) must register with the Department and be issued an FLC Certificate of Registration prior to engaging in any farm labor contracting activity. In their H2A applications, H-2ALCs required to be registered under MSPA are obligated to provide their respective MSPA FLC Certificate of Registration number and to identify the farm labor contracting activities they are authorized to perform.

In addition to meeting the same assurances and obligations as any other H-2A employer, H-2ALCs must fulfill the following requirements:

- list the name and location of each fixed-site agricultural business to which they expect to provide H-2A workers, the dates of each employment opportunity, and a description of the crops and activities the workers are expected to perform at each area of intended employment;
- submit a copy of each work contract agreement between the H-2ALC and the agricultural business to which they expect to provide workers;
- provide proof that all housing and transportation if provided or secured by the fixed-site employer complies with applicable safety and health standards; and • obtain and submit the original surety bond with the H-2A Application.

Surety Bond: The surety bond must be written to cover liability incurred during the term of the work contract period listed on the H-2A Application and must remain in effect for a period of at least 2 years from the expiration date of the labor certification. H-2ALCs must obtain the surety bond in the following amounts:

- $5,000 for a labor certification with fewer than 25 employees;
- $10,000 for a labor certification with 25 to 49 employees;
- $20,000 for a labor certification with 50 to 74 employees; • $50,000 for a labor certification with 75 to 99 employees; and
- $75,000 for a labor certification with 100 or more employees.

The bond must be payable to the Administrator, Wage and Hour Division, U.S. Department of Labor, 200 Constitution Avenue, NW, Room S-3502, Washington, DC 20210.

Where to Obtain Additional Information

This publication is for general information and is not to be considered in the same light as official statements of position contained in the regulations.

For additional information, visit our Wage and Hour Division Website:
http://www.wagehour.dol.gov **and/or call our toll-free information and helpline, available 8 a.m. to 5 p.m. in your time zone, 1-866-4US-WAGE (1-866-487-9243).**

U.S. Department of Labor
Frances Perkins Building
Washington, DC 20210

TTY: 1-866-487-9243 200 Constitution Avenue, NW

1-866-4-USWAGE
Contact Us

RETAINING AND MOTIVATING GOOD WORKERS

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Happy, driven employees are key to the success of a farm business. While ensuring a person is a good fit for their job, the environment of the workplace is the primary factor determining if employees stay long term, are productive, and feel satisfaction. There are a number of strategies a farm manager can employ to hire and retain good workers. During this conversation, we will look at strategies to find motivated workers who are a good fit for your business. We will also look at onboarding strategies that will build employee confidence about their ability to succeed, and we will discuss why it is important to create an environment where workers feel they can contribute to the success of the farm operation. The goal of the session is to build a manager's toolkit with ideas about how to address employee engagement issues and apply human resource management practices in the hiring and retention process. By getting the most productivity from a happy employee, managers are able to focus on other areas of production that will achieve farm profitability.

Learn ways to motivate and engages employees by meeting the mission and vision of the farming operation:

- Review the Job Search Process
- Prepare New Employees for Success
- Create a Culture of Engagement
- Review the True Cost of Turnover
- Identify Why is motivation important
- Differentiate Between External vs. Internal Motivation
- Learn What Really Motivates Workers

Linda has extensive experience in both community outreach and teaching. Her community outreach experience includes volunteer management, and workforce development for Penn State, Luzerne County Community College and West Chester University. She taught business, entrepreneurship, marketing, and microcomputers at Johnson College and Luzerne County Community College. She has also taught numerous workshops for Penn State Extension and Penn State Continuing Education on leadership, customer service, workplace ethics, personal finance, workplace bullying, visioning, team building and youth work-readiness skills. Linda holds a B.A. from the University of Pittsburgh in Architectural Studies and and a Master's in Business Administration from Kutztown University.
Linda is originally from Boca Raton, Florida. She has been married to her husband, John, for 29 years and they have one son, John, who attends Penn State.

TAKING THE AG-VENTURE TO THE NEXT LEVEL – AGRITOURISM COLLABORATIONS

Claudia Schmidt, Assistant Professor of Marketing and Local/Regional Food Systems, Penn State Extension
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Agritourism collaborations can take many forms: from more informal partnerships between farmers and external providers on Open Gate Farm Tours, collaborations in local or regional agritourism initiatives with listings on websites and apps, to formal arrangements between farmers in passport programs that offer incentives to visitors.

There are many different reasons why operators would like to collaborate with each other

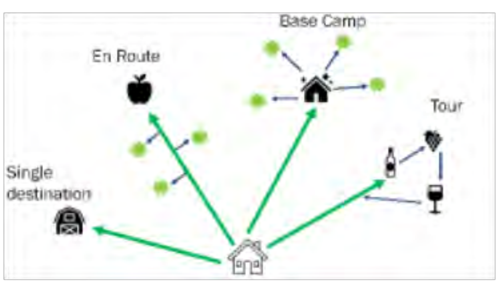
or with local and regional organizations to promote agritourism in the area. Some of these are listed below. The most important reasons for producers are likely to increase revenue and get more visitors to the farm. Local tourism bureaus need a more diverse offering for the region and create hotel revenue.

Producers
Increase revenue
Diversify offering
Reputation
Sharing advertisement resources
Share information/success stories
Receive monetary support/funding
Community awareness/outreach

Tourism Bureaus
Attract tourists (revisit)
Attract local visitors/increase purchases
Increase hotel revenue
Increase innovation in the area

The types of trails and collaborations can differ by

- Establishment (who initiated the collaboration - producer-driven, local business bureau, tourism organization)
- Geography (local trails, crossing county boundaries, state trails)
- Financing (producer fees, advertisement, grant funding)
- Administration (members, board, supporting organization)
- Visitor engagement (passport program, trail completion incentives)
- Technology (trail app, paper map, website)



When reaching out to potential collaborators, it is important to keep the goal of the collaboration and the travel patterns of visitors in mind. For example, depending on the collaborators' locations, participants could be arranged en route to a natural attraction or scene park, as a base camp (farm stays), or as a tour of different businesses (craft beverage or themed trails)

Claudia Schmidt is an assistant professor of marketing and local and regional food systems at Penn State. She worked for over ten years in the Canadian private research sector before joining Penn State. She researches small-scale agricultural producer and processor issues within the network of local food systems, focusing on agritourism.

Christi (Graver) Powell is an Agricultural Business Growth & Development Extension Educator based in Lehigh County (housed on the Business & Community Vitality Penn State Extension Team). She works with various farms and ag businesses in the Lehigh Valley and beyond in the areas of ag literacy, agritourism, ag marketing, farm transitions, and more.

(Sing-Knights, 2019). If you consider establishing a tour between a couple of collaborators and an organization like Penn State Extension, local tourism bureau, or conservation authority, here are some points to consider:

1) **Legal Considerations**
    a. Even if you only offer agritourism activities a couple of times a year, make sure that you follow local laws and requirements. For example, Pennsylvania's new Act 27 requires agritourism operators to post appropriate signage and visitors to sign waivers. More information for PA: https://bit.ly/3EVVg6E

2) **Safety Precautions**
    a. Ensure that you perform routine perimeter and other safety checks for areas in your operations where the public will be walking and participating in activities

    b. If you have animals, make sure you follow biosecurity measures for the health and safety and visitors and workers (restrooms, handwashing, petting zoo/animal interactions, etc.) More information: https://bit.ly/3DJZw7S

3) **Support in Managing Visitors**
    a. Ensure you have a proper number of adequately trained staff and/or volunteers to help coordinate agritourism and other essential activities (parking, point of sales, maintenance, etc.). It often "takes a village" to help run these types of operations, especially during Open Gate Farm Tour weekends when there can be many people visiting all at once or throughout the day. More information on PSU's Open Gate Farm Tour: https://bit.ly/3DVJKat

4) **Taking an Active Part in Educating the Public about Agriculture (Agricultural Literacy)**
    a. One of the goals of opening your farm to visitors is to provide agricultural education by raising awareness of the importance of supporting the local farming community and helping to build good relationships with non-farm neighbors.

    b. For example, at least some sort of educational activity (at no cost) is required to participate in PSU Extension's Open Gate Farm Tours. Hayrides with a narrative about the farm, a tour of the barn, or a lecture on how to grow pumpkins are a few examples of educational activities that could be offered. Penn State Extension has volunteer and youth programs such as 4-H, Master Gardeners, and Master Water Stewards that could add value to your operation by setting up a table with educational activities and materials on Open Gate weekends.

5) **Set Expectation and Ensure Proper Communication**
    a. For example, producers must be in good communication with Penn State Extension staff leading up to Open Gate weekends (to make sure the correct info for marketing is collected, signs and other brochures are picked up, etc.) and after Open Gate weekends (to collect data on visitor numbers, ideas for future tours, etc.). E-mail is often the preferred communication route, but paper mailing can be done.

6) **Survey and Evaluate**
    a. Keep evaluating the partnerships and collaborations you have created. Even though you are building personal relationships, it is essential to determine if you are reaching your goals. If you do not, communicate your challenges with your collaborators.

Sources and Further Reading:

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COMMUNICATING WITH THE MEDIA AND CONSUMERS DURING A CRISIS

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There is a great deal of competition for media and consumer attention with the many ongoing crisis impacting our society. Consumers are bombarded with conflicting messages on a myriad of issues which can lead to a general distrust in the sources of information. People are creatures of habit and often look for information that confirms their established beliefs instead of looking for alternative viewpoints. This encourages the media to simplify their messages into mini-commercials that attract attention and avoid the complexities of educating their readers and viewers. Media often gravitates to reinforcing the fears and concerns of the public, instead of providing practical solutions. You can counteract a negative media story about your farm by staying focused on a few positive key points with confidence. When interviewed, provide positive solutions to the problem at hand.

You can change the dynamics of a media interview by preparing ahead and staying focused in a positive manner of how you are doing well despite the issue at hand. For example, if you are experiencing drought conditions, you could focus on how your fruits or vegetables may taste sweeter due to the concentration of sugars with less rainfall and focus on how your control of irrigation can decrease the amount of fungicides needed to produce a quality product. Think of yourself as the consumer seeing, hearing or reading your story. If you tell your customers you are experiencing problems, they are likely to shop somewhere else so they can purchase quality products. Few people will purchase based on sympathy. Unfortunately, many of my farmers found this out the hard way after telling their hard luck story and losing many of their customers for the season.

During one of the past food-borne illness outbreaks on spinach, one of our growers appeared on several national media outlets. The grower focused on how he followed food safety guidelines and tested his irrigation water that was sourced from a clean well. He was interviewed standing by his huge overhead irrigation lines and stressing the purity of his irrigation water throughout the interview. He spoke with great confidence and knowledge and his preparedness for the interview sent a clear positive message to many consumers. Although there was a dip in sales, eventually consumer confidence was regained and sales went back to normal.

In the case of the COVID 19 pandemic, many farmers adapted quickly with online sales and timed pickup or drop off of farm products. Creative farmers provided timed online ticketing of pick-your-own and agritourism events to

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Bill has created and hosted over 22 television programs for statewide Public Television and developed an accompanying educational web site that received over 7 million visitors. He has written hundreds of articles for several major newspapers in New Jersey. He created the online RU Ready to Garden Series with colleagues to provide Extension education throughout the COVID 19 pandemic. Bill has won over 100 state, regional and national awards for his Cooperative Extension programs, publications, media and research at the NJAES.

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control crowd sizes and provide an extra margin of safety. The added precautions of well trained staff throughout the farm that were wearing masks and keeping all public areas clean and safe helped to attract loyal customers. Consumers appreciated purchasing their favorite local products in a safe and comfortable environment. In some cases, farms increased their sales during the pandemic because of their ability to adapt quickly and provide convenience and safety to the consumer.

Here are a few tips for interviewing with the media during a crisis:

- Select an attractive location for the interview that is quite with beautiful surroundings that tell the story of your farm.
- Have visual props around you that will help you to focus and remind you of what you want to say and possibly display during the interview
- Have no more than two or three key positive points that you mention several times throughout the interview
- Tell a great short story that gets your point across while capturing the attention of the media and consumers
- Wear nice clothing and avoid wearing a hat or sunglasses that hide your eyes and may make you look suspicious
- Ask the reporter to send you questions ahead of time if possible so you can prepare. You can also prepare questions ahead of time to assist the reporter.
- If you do not feel comfortable in front of reporters then find someone that does feel comfortable with reporters
- Rehearse before the interview with a family member or friend or stand in front of a mirror
- Make sure your body language is portraying confidence and honesty
- Always respond with clarity and concise statements even when telling a story- remember that most interviews are edited down to a few key statements
- Stay positive. If the reporter goes down a negative path, redirect the interview with a positive solution and project confidence and knowledge

Use these same tips when creating social media content. Always accentuate the positive aspects of your farm and the products you produce. You have worked very hard to be successful as a farmer. Your honesty and preparedness for communicating with media and consumers will help to boost confidence during any crisis you may face. Hopefully consumer confidence will help to educate consumers and increase profits

ROOTSTOCK SELECTION AND ROOTSTOCK-SCION INTERACTION FOR PA FRESH MARKET TOMATO PRODUCTION IN HIGH TUNNELS

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Continuous tomato cropping in greenhouses and high tunnels has resulted in frequent incidences of soil-borne diseases. These diseases usually cannot be controlled using fungicides and a growers' only management option is to grow another crop or move the structure. Disease pressure has frequently reached a very high level and this has enabled the pathogen to overcome genetic resistance in the tomato varieties grown. As a result, some growers have started using grafted tomato plants which have higher levels of disease resistance. Seed companies have responded to this need by introducing new rootstock varieties. These new rootstocks have varying levels of vigor and different types and/or levels of disease resistance and unknown impacts of tomato fruit yield and quality. The purpose of this study was to evaluate four rootstocks grafted with two varieties of tomato for growth and yield in a high tunnel.

Four tomato rootstocks, selected for vigor and disease resistance, were grafted with two scions 'Red Deuce' (HM Clause) and 'Roadster' (Sakata Seeds) and planted in a 27'x96' high tunnel at the Penn State Southeast Agricultural Research and Extension Center in Manheim on April 14, 2021. The rootstocks were 'Estamino' (Enza Zaden), 'Maxifort' (De Ruiter Seeds), 'Synergy' (Sakata Seeds) and 'Kardia' (Syngenta) and were grafted by a commercial grower. In addition, non-grafted plants of each variety were used as guards on row ends for comparison. The tomato plants were grown on narrow beds covered with black plastic and watered with trickle irrigation. Fertility was managed according to soil test results and recommendations in the 2020-2021 Mid-Atlantic Commercial Vegetable Production Recommendation Guide. Plants were grown using the stake and weave system. There were eight total rootstock/scion combinations and two non-grafted (own root) treatments. Five plants per rootstock/scion combination comprised a plot while two non-grafted plants comprised a plot for the guards on row ends. There were four rows in the high tunnel and each represented a block and contained a plot of all possible rootstock/scion combinations for a total of four replicates per treatment.

Harvest started on July 2 and ended on September 20, 2021. All harvested fruit were graded into marketable and cull (non-marketable) and each group was counted and weighed. Marketable fruit was separated into #1 and #2 grades and then sized into the following categories: >4", 3.5-4", 3.0-3.5", 2.75-3.0", 2.5-2.75", 2.25-2.5", and 2.0-2.25". Fruit <2" were considered non-marketable and culled. A biometric analysis was done on July 8 to measure plant growth as impacted by the various rootstock/scion combinations. Plants were removed from the rows and divided into leaves, stems and fruit and both fresh weight and dry weight were measured.

'Red Deuce' grafted into 'Maxifort' had the largest average single fruit weight in #1 and #2 fruit in all size categories. Average fruit size on other rootstocks was similar and non-grafted plants had the smallest average fruit sizes. 'Red Deuce' also had the highest total yield of #2 fruit when grafted into 'Maxifort' but the highest number and yield of #1 fruit was observed in plants grafted into 'Synergy'. 'Red Deuce' also had the lowest total weight of culls when grafted into 'Synergy'.

'Roadster' had the highest fruit number and total yield of #1 fruit when grafted into 'Synergy'; average single fruit weight was similar on all rootstocks and smallest on non-grafted plants. The highest total numbers and yields of #2 fruit and total marketable fruit were on 'Estamino' and 'Maxifort'. Cull number and total weights were similar on all rootstocks.

For both varieties, the main reason for cull fruit was blotchy ripening but other defects were cracking, insect injury

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and general fruit appearance.

Comparing the two tomato varieties across rootstock, 'Roadster' provided higher fruit number and marketable yield compared to 'Red Deuce'.

'Roadster' had higher total plant dry weight than 'Red Deuce' only when grafted into 'Estamino'; all other rootstock/scion combinations had similar total plant dry biomass. 'Roadster' had higher leaf dry weight and fruit dry weight than 'Red Deuce' when grafted into 'Estamino'. 'Red Deuce' had higher fruit dry weight when grafted into 'Maxifort' compared to 'Estamino' while 'Roadster' had higher leaf dry weight when grafted into 'Estamino' than when grafted into 'Maxifort' and 'Synergy'.

Plants in this trial became very large by the end of the study, particularly those grafted with 'Roadster', which presented some management challenges. Growers looking to use rootstocks for disease management in high tunnels and greenhouses should plan on some trial evaluations to find the best rootstock/scion combination for their growing system and market. We hope to repeat this trial in 2022 to gather additional data on the rootstocks we trialed this season.

Table 1. Tomato fruit yield and size for #1, #2 and cull fruit for 'Red Deuce' on four rootstocks and non-grafted grown in a high tunnel at the Penn State Southeast Agricultural Research and Extension Center in 2021. Weights are per plant and in lbs.

Rootstock	Total Number #1 fruit	Total Weight #1 Fruit	Average Fruit Weight	Total Number #2 Fruit	Total Weight #2 Fruit	Average Fruit Weight	Number Cull Fruit	Weight of Cull fruit	Total Marketable Fruit Number	Total Marketable Fruit Weight	Average Marketable Fruit Weight
Estamino	15.8	12.5	0.80	13.5	9.8	0.73	23.0	14.0	29.3	22.4	0.76
Kardia	14.8	11.7	0.79	13.9	9.9	0.77	23.4	14.2	28.7	21.6	0.78
Maxifort	12.5	11.0	0.88	13.8	11.2	0.81	22.7	14.5	26.3	22.2	0.85
Synergy	18.3	14.6	0.80	12.7	9.2	0.73	21.9	12.8	31.0	23.8	0.77
Non-grafted	16.8	12.9	0.77	13.0	9.0	0.69	27.3	14.9	25.7	21.9	0.73

Table 2. Tomato fruit yield and size for #1, #2 and cull fruit for 'Roadster' on four rootstocks and non-grafted grown in a high tunnel at the Penn State Southeast Agricultural Research and Extension Center in 2021. Weights are per plant and in lbs.

Rootstock	Total Number #1 fruit	Total Weight #1 Fruit	Average Fruit Weight	Total Number #2 Fruit	Total Weight #2 Fruit	Average Fruit Weight	Number Cull Fruit	Weight of Cull fruit	Total Marketable Fruit Number	Total Marketable Fruit Weight	Average Marketable Fruit Weight
Estamino	23.9	16.6	0.69	21.5	13.3	0.62	29.0	14.8	45.4	29.9	0.66
Kardia	23.4	17.0	0.72	16.6	10.4	0.63	28.2	15.7	40.0	27.3	0.68
Maxifort	20.4	s14.8	0.73	21.3	12.9	0.60	27.6	14.4	41.7	27.7	0.66
Synergy	25.9	18.6	0.72	19.7	11.8	0.60	27.6	14.3	45.6	30.3	0.67
Non-grafted	23.9	13.9	0.67	19.0	12.0	0.63	27.4	13.3	42.9	27.9	0.65

SOIL AND TISSUE TESTING AND THEIR INTERPRETATION FOR IN-SEASON NUTRIENT PROGRAM ADJUSTMENTS IN HIGH TUNNEL

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High tunnel production systems are becoming increasingly popular in the Mid-Atlantic region for the benefit offered in terms of crop protection from adverse environmental conditions and as a crop season extension tool. Compared to open field, high tunnel production systems offer the opportunity to increase crop yield and quality, thereby increasing resource use efficiency. The microenvironmental conditions created within high tunnels mitigate unpredictable and most severe open field environmental conditions, and have an impact on plant growth, soil microbial activity, and water and nutrient dynamics. Therefore, agronomic practices including water and nutrient management should be adjusted in high tunnels compared to open field production systems. On one hand, the relatively higher temperatures and the exclusion of precipitations associated with high tunnels lead to faster and higher plant growth, higher crop yield, and longer crop cycles, which would suggest water and nutrient requirements are higher in a high tunnel compared to open field production for a given crop. Such assumption often induces high tunnel growers to apply higher levels of nutrients compared to what they would apply for the same crop grown in open field. However, the relatively higher soil temperatures usually recorded in high tunnels may be also associated with higher mineralization rates of the soil organic matter and increased availability of minerals for plants. Moreover, the exclusion of precipitations and the higher evapotranspiration rates observed in high tunnel production systems contribute to create microenvironmental conditions that are typical of semi-arid environments and that tend to favor the upward movement of water and nutrients in the soil, determining the accumulation of the excess of nutrients in the top soil layer, and the consequent increase of salinity levels in the soil, which over time may reach levels that are detrimental for plant growth. To prevent soil salinity build-up and preserve soil health, assuring the long-term sustainability of high tunnel production systems it is particularly important to implement rational water and nutrient management techniques.

Commonly high tunnel growers use fertigation to deliver nutrients, which allows in-season adjustment of the crop fertilization based on soil and/or plant tissue testing using a “corrective” fertilization management approach rather than a “preventive” approach commonly used in open field vegetable production. Nevertheless, selecting the best method to monitor the crop nutritional status or the level of nutrients in the soil and interpreting the results of the analysis to adjust the fertilization plan may be challenging. Among the different in-season monitoring methods currently available, we can distinguish i) plant monitoring and ii) soil monitoring methods.

The most popular approach used by high tunnel growers in the Mid-Atlantic region is likely the analysis of the plant, conducted using oven-dried and milled leaf-tissue samples. The leaf-tissue analysis is conducted sampling the most recently mature leaves (3rd-4th leaf from the top) from representative plants within a given growing area and bulk samples of at least 15-20 leaves per area are shipped to an analytical laboratory for analysis of the mineral profile, including the analysis of total nitrogen (N) and the elemental analysis of the main macronutrients (P, K, Ca, Mg, S), sodium (Na), and micronutrients (Fe, Zn, B, Mn, Cu, Mo). The results of the analysis are usually expressed as concentration (% or ppm) on dry weight basis and are shared with the grower a few days after the submission of the samples in a report that generally indicates whether the concentration of a given nutrient is considered deficient, low, sufficient, high, or very high for the given crop at the sampling stage. The analysis of leaf tissues is repeated collecting samples every 3-4 weeks, and results are generally sent back to the grower within 2-7 days after sample submission. This type of plant tissue analysis is one of the most reliable and complete approaches to examine and inform the grower on the crop nutrient status. Laboratories providing this type of analytical service, usually compare measured values for each crop and stage with database and/or literature values indicating ranges of deficiency, sufficiency, or excess for a given crop, and provide recommendations based on this comparison. The deficiency, sufficiency, and excess ranges for a given mineral and crop stage have been generally defined based on experimental data. Although the analysis is very reliable, a limitation of this approach is that reference values often have been defined under specific environmental conditions and were determined on varieties and in cropping systems that are not always consistent with current growing systems and varieties used. Moreover, while the analysis provides information on the plant nutritional status and indicates whether “more”, “no” or “less” fertilizer is needed for a given crop and element, the analysis and the reports generally provided to the growers do not provide specific information about how to adjust the fertilization and do not inform the grower on what is happening at the soil level. Other limitations of this method are i) cost of the analysis, ii) variability of the results based on the age/position of the leaves sampled, iii) and in some cases the time required to obtain the results.

Another method used to monitor the plant nutrient status is the so called “tissue testing” or analysis of the plant sap. In this case leaf tissue samples are collected from representative plants of a given crop and depending on the crop the leaf petiole or midrib are used to extract the leaf sap, which is then analyzed using different methods, including rapid sap testing kits. One of the main advantages of this approach is the opportunity to do the sap analysis directly on-farm using relatively low-cost rapid test kits obtaining immediate information on the crop nutrient status. However, the analysis of the plant sap can be applied only on some nutrients and is considered less reliable compared to the analysis of dry plant tissue done in a laboratory. Although the plant sap analysis can provide useful information, the main limitation of this method is that results are affected by the plant water content and by variations of the water and mineral content within the plant at different time of the day and during the growing season. Therefore, when using this method, it is important to be consistent by sampling leaves always at the same time of the day and sampling leaves at the same development stage. Moreover, the high concentrations of nutrients in the plant sap and the use of rapid test kits does not guarantee the same level of accuracy of the analysis conducted in a laboratory. Therefore, more experience is required in using and interpreting the information obtained through sap analysis. Also in this case, deficiency, sufficiency, or excess ranges have been defined for the concentration of the main macronutrients in different crops at different crop stages.

The alternative to plant analysis and tissue testing is the in-season analysis of the soil which can be done on moist or oven-dried soil samples using different extractant solutions or analyzing the soil water extract with the Sonneveld method developed for greenhouse soil production in The Netherlands. The analysis of the soil extract can be done using laboratory protocols or rapid analysis kits. Main parameters monitored in the soil are pH, electrical conductivity, nitrates, ammonium, and other macronutrients. The main advantage of this approach is the opportunity it offers to monitor the soil and prevent nutrient deficit or excess before we can detect it on the plants.

GRAFTED AND NON-GRAFTED TOMATO RESPONSE TO NITROGEN INPUTS IN HIGH TUNNEL PRODUCTION SYSTEMS

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Fresh market tomatoes are the most common vegetable crop grown in high tunnel systems in the Mid-Atlantic Region and there is an increasing adoption of grafted tomato plants due to the benefits offered by vigorous rootstocks. Grafted tomato plants offer improved resilience to many stresses associated with high tunnels, including high salinity, alkalinity, boron excess, high and low temperatures; and increased resistance to some soil-borne pests and pathogens. Additionally, grafted tomatoes can improve nutrient uptake and improve water-use efficiency which can result in increased yields and fruit quality. In high tunnel environments, there is some confusion about the nitrogen needs and responses of grafted plants compared to non-grafted plants. The perception of grafted tomato plants is that they grow larger and more quickly, which would suggest that they might have a larger demand for nitrogen and other nutrients compared to non-grafted plants. At the same time, but in contrast, the vigorous growth of grafted plant roots, resulting in a larger root system to take up nutrients from larger volume of soil, suggest that grafted plants may more efficiently take up nutrients and not require as much fertilization compared to non-grafted plants. Currently there are not specific differentiations in nitrogen rate recommendations between grafted and non-grafted tomato plants because of limited research on the topic.

In the 2021 growing season, at the Penn State Russell E. Larson Agricultural Research Center, a study was conducted to better understand the difference in nitrogen responses between grafted and non-grafted fresh market tomatoes grown in high tunnels. ‘Red Deuce’ fresh market tomato plants, both non-grafted and grafted onto DR0141TX (De Ruiter Seeds), were grown in a high tunnel under four different nitrogen rates of: 0 lb./acre, 75 lb./acre, 150 lb./acre and 300 lb./acre. Plant yield, quality and nutrient use efficiency were assessed. There was little effect of nitrogen on overall yield, however plant size and biomass were affected by the different nitrogen treatments. Higher nitrogen rates cause larger plants, but similar yielding plants compared to lower nitrogen rates. Grafted plants grew larger and had higher yields compared to non-grafted plants. These results suggest that nitrogen rate does not have as large of an effect on yield and quality of tomato crops as the difference between grafted and non-grafted plants. Additionally, grafted plants performed very similarly, regardless of the amount of nitrogen applied. These mixed results of the response of grafted and non-grafted to nitrogen suggest that while grafted plants improve yields, they may not need higher fertilization rates.

WEED CONTROL IN BEETS: CURRENT HERBICIDES AND NOVEL TECHNOLOGY

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Introduction: Table beets are not competitive with weeds early in the growing season; as such, the crop must be intensively managed to prevent against losses to yield quantity and quality. Marketable yield can be reduced by 53% if weeds are allowed to remain in competition with the crop season-long. Few active ingredients are available for use in beets and many are rated fair to poor for the control of many species including pigweeds (Amaranthus spp.), lambsquarters (Chenopodium album), nightshades (Solanum species), velvetleaf (Abutilon theophrasti) and ragweed (Ambrosia artemesiifolia). For example, ethofumesate is effective against nightshades but not lambsquarters while phenmedipham controls lambsquarters but not nightshade. Triflusulfuron is can control velvetleaf and but not ragweed while clopyralid is effective against ragweed but not velvetleaf. S-metolachor, which is an effective tool against grasses and nutsedge, provides poor control of lambsquarters.

Pre-emergence weed control: Soil-applied herbicides (also called residual herbicides) are incorporated into the soil solution and are taken up and active against newly germinated/emerging seedlings. Few pre-emergence herbicides are registered for use in table beets and not all are registered for use in all states (consult labels before applying). No single product will control all species and not all herbicides will persist in the soil, equally. If the products are not activated in a timely manner, weed control will be severely reduced. Ro-Neet (cycloate), Dual Magnum (S-metolachlor), and Nortron (ethofumesate) are available residual weed suppression. Ro-Neet is pre-plant incorporated and is effective against some broadleaves, including pigweeds as well as grasses. Dual Magnum is best at controlling grasses, pigweeds, galinsoga and nightshades. Nortron, which can be applied with Dual-Magnum, controls smartweeds, mustards, and wild buckwheat, nightshades, smartweeds, and mustards. Despite being registered in beets, pre-emergence herbicides can cause some injury to beets, reducing crop vigor.

Post-emergence weed control: Post-emergence herbicides are applied for the control of emerged weed species and are most effective against smaller-sized plants. Like the pre-emergence products, they, too, can reduce beet vigor, particularly if plants are small and/or stressed. Also like the pre-emergence herbicides, there are few registered products and their spectrums are limited, necessitating judicious applications to suppress unwanted vegetation. In addition to providing residual control, Nortron can also be used post-emergence. Like Nortron, UpBeet (triflusulfuron) is effective against mustards, but is weak on smartweeds and nightshades; it is a good product against velvetleaf. Spin-Aid (phenmedipham) provides control of broadleaves including common lambsquarters, purslane, common ragweeds and mustards, and can be applied when beets have at least four true leaves. Stinger (clopyralid) is selective against members of the aster (like ragweed and galinsoga) and legume families and can be used to control smartweed and nightshades. Grass herbicides, like Select Max (clethodim), are effective when applied to actively growing plants.

Herbicide use: When choosing and using an herbicide, be aware of the weeds present in the selected field and apply products accordingly, pre- and post-emergence) to provide season-long suppression. Be aware that beets can be injured by herbicides registered in the crop and pay attention to stressful environmental conditions that could impact crop growth (and enhance its sensitivity to chemical weed control products). Weeds that are small, but vigorously

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growing (i.e. not stressed) are ideal targets for herbicide applications. Remember that weed control should start before the crop is even planted, which may mean engaging is aggressive suppression practices in preceding crops to prevent or reduce weed seed set. Be mindful of crop rotation restrictions as setbacks to beet emergence and development will reduce crop competitiveness.

Alternative weed control: Electrical weeders, like the commercially available, tractor-mounted Weed Zapper™, control weeds that are in-row and above the crop canopy by applying a high voltage electric current directly to unwanted vegetation. The flow of electricity through the plant generates heat, which causes water in cells to vaporize; in turn, the resulting pressure causes tissues to burst and die. The first electrical weeders were patented in the 1880's. In the 1970's and 1980's, electrical weeders were successfully used in sugar beets to control weeds and bolting crop plants. Personal communications with weed science colleagues across the US suggest that there is a resurgence in grower interest in electrical weeder technology among growers. This includes New York, where a large organic farm (Kreher's family Farms) and a custom operator (Preferred Grain) have established collaborations with Cornell and Cornell Cooperative Extension to optimize the technology. The available literature is largely out-of-date, and trials were conducted using prototype equipment and/or under growing conditions that are not representative of New York's current production environments. This necessitates university-based research to evaluate the efficacy and crop safety of commercially available electrical units to support grower adoption. Results from observational studies in both organic soybean and organic table beet fields in New York showed significant reductions in weed biomass and reproductive output where growers used the commercially available Weed Zapper™ for vegetation management as compared to check plots (no electrical weeder activity). Under optimal use conditions (i.e. applied to succulent, vigorously growing weeds), fresh weight and reproductive output were reduced by 60% to 90%, depending on species. Injury was not observed in soybean but did occur in beets; the damage was presumed to occur under dry soil conditions where the electrical current passed preferentially through beet roots. These results suggest that formally designed and replicated trials are needed. Growers' decisions to invest in novel technology will require unbiased data describing the conditions that will either improve or limit weed control success.

WINTER SPINACH PRODUCTION AND PEST MANAGEMENT

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New England vegetable growers have found that demand for fresh, local greens is nearly limitless during the winter months. Prices for fresh, organic spinach average about $10/pound, so growing fresh greens in winter can be a profitable addition to your farm business. Other benefits of growing winter greens reported by growers include maintaining employees and customers year-round. However, not everyone will want to give up their short winter "break", or want to invest in a new high tunnel or specialized equipment. Therefore, we undertook the following research and education project in order to help document the potential profitability of different types of production systems, and learn more about insect, disease, and weed pests that limit yield and profits.

Production systems range from simple low tunnels to highly mechanized high tunnel production or heated greenhouses and everything in between. We identified growers producing winter spinach across this range and conducted enterprise budgets with three farms. Factors that contributed greatly to the profitability of the crop were: seeding versus transplanting (labor and supplies), harvest time, plant density, leaf size at harvest, cost/pound, and disease incidence.

Recommendations for Improving Profitability of Winter High Tunnel Spinach Production

- **Variety Selection:**
  - o **Plant varieties with the latest, broadest downy mildew resistance (1-17):** In our most recent variety trial, Dallas, Crosstrek, Nembus (all 1-17 varieties), Patton (1-15, 17), and Responder (1-12, 14-16) all performed well.
  - o **Plant multiple varieties** so that all gaps in resistance are covered and to maximize protection against novel strains
- **Bed and Tunnel Preparation:**
  - o **Keep soil pH above 6**
  - o **Prepare uniform beds:** We have found that spinach stand is very sensitive to soil compaction and moisture, so efforts to make uniform, slightly raised beds can improve stand.
  - o **Set up uniform irrigation:** Spinach seedlings are sensitive to damping off in cold soil, so ensuring that there are no wet spots in your tunnel can help reduce damping off and improve stand.
- **Seeding & Production:**
  - o **Increase planting density:** We use a rate of 69 seeds/sq ft; growers we've surveyed have used up to 140 seeds/sq ft
  - o **Use PSNTs to time sidedressing:** Pre-sidedress nitrate tests measure the available nitrate in the soil at the time of sampling. Nitrate moves quickly through soil, and it's not fully known how it behaves in cold high tunnel soil in the winter months when the crop is growing slowly. When nitrate levels drop below 30ppm, it's recommended to sidedress. We sidedress through overhead irrigation, using OMRI-listed water-soluble calcium nitrate. PSNTs can be taken monthly to monitor soil nitrate levels. PSNTs are available through the UMass Soil Lab for $15 each.
  - o **Use row cover to speed up growth but not to keep plants alive:** Spinach is very cold sensitive and won't be harmed by cold temps as long as the leaves aren't disturbed while frozen. Row cover may speed up growth slightly but also adds labor, so don't use it to simply keep the plants alive.

Sue Scheufele is an Extension Educator with the UMass Extension Vegetable Program, where she enjoys working with growers to solve crop and pest management issues and conducting applied research on vegetable pest management. Sue received a Master's degree in Plant Pathology from Cornell University in 2013. She grew up in Worcester, MA and currently resides in Deerfield, MA.

- **Harvesting & Sales:**
  - **Harvest by clear cutting:** From what we have seen, winter markets tend to be forgiving of the cut leaves that tend to occur from clear cutting. Clear cutting, either mechanically or by hand, is a huge time/labor saver. We have seen different varieties respond differently to clear cutting as well – some varieties have a growth habit where the developing leaves remain uncut within the growing point. In our trials, Patton, Responder, and Crosstrek all had "uncut" regrowth after being clearcut.
  - **Harvest larger than babyleaf:** If your markets will allow it, this is an easy way to increase yields
  - **Increase price/lb:** Get a fair price! We've seen people charge anywhere from $5-14/lb and customers seem willing to pay premium prices for winter greens.

Notable Pests of Winter Spinach

Chickweed is a winter annual and thrives in cool moist low-night conditions found in winter greens production systems. Chickweed can cause >50% losses. Management can include flaming, stale seedbeds, and cultivation or hand-weeding. A new and potentially effective strategy to control chickweed is soil steaming. Steaming to a 2-inch depth at 140-160F for 30 minutes can kill weed seeds and many pathogenic microbes like Fusarium spp., Pythium spp., Rhizoctonia spp. and more.

Steaming Resources:

- https://www.uvm.edu/sites/default/files/UVM-Extension-Cultivating-Healthy-Communities/horticulture/VVBGA/AnnualMtg21/Maden_Steaming_Tunnels.pdf
- https://www.youtube.com/watch?v=M0mbyEOlO70
- https://sioux.com/soil-sterilization

Aphids can infest crops at any time or growth stage and reduce crop marketability as they contaminate the harvested produce. Several species of aphids may be present including green peach, foxglove, and potato aphids. Aphids are routinely controlled using biocontrol organisms such as predatory midges, wasps, and ladybeetles, but unfortunately, activity of these insect biocontrols is drastically reduced at cold temperature. We recommend scouting often to catch problems before they become severe, to use an action threshold of 1 aphid/leaf, and to focus control early in the season before temps drop and keep up with sprays until the problem is resolved, as demonstrated by scouting.

Winter cutworms are an emerging problem in many tunnels. These caterpillars hide in the soil during the day and come out to feed at night, causing large spots or gashes in the leaves. Many insecticides are labeled including B.t. products like Dipel as well as spinsoad products such as Entrust (foliar) or Seduce (soil bait) but efficacy of these materials on these particular cutworms and at cold temperatures is not known. Outbreaks are sporadic and spraying preventively can be a challenge, and data on efficacy is limited. Hand-removal at night using a headlamp or blacklight can be effective.

Spinach downy mildew can cause significant losses and is becoming a more regular problem in the Northeast in winter production systems. The pathogen exists as races and is controlled in spinach production areas through the extensive use of resistant varieties. In the Northeast, recent races we have typed were race 12, 15 and novel strains. The latest and greatest resistant varieties are not always available for purchase in the Northeast, but we are working with seed producers and distributors to increase awareness of the emerging downy mildew problem in the Northeast and have conducted variety trials to identify cultivars with resistance to the newest races that grow well in a winter tunnel environment—some of the varieties that have stood out in recent trials were Dallas, Crosstrek, Nembus, Regor and Kiowa.

Damping off is caused by several soil-borne pathogens that kill seeds as they germinate causing poor stands, or kill seedlings and small plants after emergence. Intensive year-round production in tunnels causes these pathogens to build up and flourish. To reduce severity of damping-off, avoid seeding into cold, wet soil; avoid overcrowding or seeding too deeply; create uniform beds to manage soil moisture and avoid wet and dry areas; increase airflow and light penetration and decrease humidity. Key to managing damping-off long-term is improving soil microbial health in the tunnel through practices like cover cropping, amending with compost. Soil steaming may also help to eliminate pathogens in the top 2" of soil. We are currently investigating the effects of priming seed to speed germination and reduce damping off. Results will be presented in February.

Cladosporium is a foliar leaf spot that we see commonly in winter spinach but rarely see in the main season, as it thrives in cool conditions. Tan spots develop on the leaves and a dark green to brown sporulation occurs. Managing fungal leaf spots is dependent on reducing leaf wetness and humidity, removing affected plant tissue and destroying residues promptly and using a 2-year crop rotation to avoid building up inoculum. Cladosporium may not be on a lot of product labels but products labeled for Cercospora should be effective for Cladosporium as well, if the pest does not need to be on the label in your state.

TIPS AND TRICKS TO GROW STORAGE CROPS

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Consumers in the Northeast are increasingly looking for local produce even during the winter. And although there are some crops that can be grown, or at least maintained through the winter, this talk will focus on crops grown in the summer and fall and stored for the winter. We won't focus on traditional storage crops like potatoes, onions and cabbage which are covered more thoroughly in other sessions. Our focus will be on winter squash, sweet potatoes, beets, carrots, turnips, rutabagas, leeks, and celeriac.

Successful storage of vegetables starts with producing high-quality, disease-free produce. Remember - the quality of your product will not improve in storge. 'Garbage in- Garbage out' is very true when it comes to stored vegetables. As my colleague at the University of Vermont, Vern Grubinger says, 'Vegetables are alive, even after harvest, but the reality is they are doomed to die--the only question is when." Your goal is to provide that life support, to reduce respiration - which serves to maintain sugars; and reduce transpiration which reduces dehydration and shrinkage.

There are three stages growers need to think about when growing storage vegetables – 1) field production, 2) harvest and handling and 3) actual storage. As you can imagine, the details for each of these stages is quite crop specific but there are certainly some generalities that cut across all of them.

Field Production – Variety choice (some may be better for storage); excellent pest management; optimized soil fertility and irrigation; time plantings for harvest at appropriate times - Crops like carrots and beets can stay in the field long into the fall while sweet potatoes need to be removed prior to the first frost or immediately after. Winter squash can handle a light frost but don't leave in the field too long.

Harvest and Handling – Harvest at optimum time – at peak maturity or just prior; be gentle to minimize bruising; minimize field heat (early AM harvest, keep shaded); cure when appropriate; don't overcrowd; trim or wash when appropriate.

Storage – Optimum relative humidity and temperature; good air circulation; keep away from ethylene producers (apples), don't overpack bins.

For squash, how can you tell when they are at optimum maturity and ready for harvest? You can try these methods.

- Rind is hard and can't be pierced by thumb nail
- Subtle color change (slight in Butternut and light-colored squash)
- Handle/stem turns from spongy to corky/hard
- Refractometer (Brix >11%)/Dry Weight (>18%)

Curing is very useful for many storage crops. It helps to heal cuts and bruises, promotes drying of plant parts like onion necks, can increase storage time and increase sugar content and flavor. The optimum conditions depends on the vegetable. For sweet potatoes, cure at 80-85F and a RH of 85-95% for 5-7 days. Winter squash would be a similar temperature and humidity but for a longer period of time – a minimum of 10 days. Many growers will use a greenhouse to cure squash and potatoes and keep the floors wet to increase RH. And cover squash to avoid sunscald – Kabocha squash are especially sensitive to the sun.

Steve Reiners is Professor in 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. He and his wife Beth are the proud parents of two children and happily welcomed there first grandchild, Adelaide this past summer.

Acorn squash do not need to be cured but can instead go right into storage.

Check on the vegetables as they cure and remove ones that show any rots or softening. Only put squash that are firm and free of rots in storage. Squash will do best if a 1-inch stem is left on the fruit.

Although you can find specific guidelines for vegetable storage, in general, there are five general categories. These include.

- **Cold and moist** = 32°F and 90-95% RH. Beets, cabbage, carrots, cauliflower, leeks, rutabagas, and turnips.
- **Cold and dry** = 32°F and 65-70% RH. Garlic and dry onions. (Store seed garlic at 50°F.)
- **Cool and moist** = 45°F and 90% RH. Potatoes for table stock.
- **Warm and mois**t = 57°F and 85-90% RH. Sweet potatoes.
- **Warm and dry** = 55°F and 50-70% RH. Winter squashes, including pumpkins

Table 1. Winter squash storage tips

SQUASH TYPE	COMMENTS
Cucurbita pepo • Delicata • Sweet Dumpling • Acorn • Spaghetti • Pie pumpkins	Can be eaten immediately or stored for 2-4 months
Cucurbita maxima • Buttercup • Kabocha • Hubbard	Highest dry matter of all squash – too dry to eat at harvest. Storage time is needed with exception of mini Kabochas which can be eaten at harvest. Store 2-5 months
Cucurbita moschata • Butternut	Best stored 1-2 months before eating. Store 3-6 months

GROWING BRUSSELS SPROUTS FOR FALL AND WINTER HARVESTS

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Brussels Sprouts have become more popular as consumers have discovered the health benefits of Brassicas (kale!) and the convenience of sheet pan dinners and roasting winter vegetables. There certainly are opportunities for sales of Brussels Sprouts, but there are also considerable challenges in production.

Brussels Sprouts are traditionally grown in areas with mild, maritime climates. Brussels Sprouts do not handle stress very well, because good and even development of the sprouts depends on reliable and even dominance of the growing point at the top of the stem (apical meristem). The plant needs to grow at a steady and even pace to allow the stem to reach as much length as possible. The steady growth allows the apical meristem to assert strong dominance over the side-shoots (sprouts) until the second half of the season. Once the plant has used up most of the available fertility and the stem has reached maximum height the sprouts will begin to develop. Ideally all sprouts develop at the same time, but the lower sprouts will typically develop first and the top sprouts will start their development a bit later.

Under stress (drought, heat, too much water, fertility stress, soil compaction, etc.) the plants will grow at an uneven pace. When the plants are stressed to the point of no-growth (in the heat of summer, for example) the apical meristem stops growing and its dominance over the side-shoots is lost. When the plants start growing again the lower sprouts will develop too fast, and this will result in uneven sprout development along the stem. The lowest sprouts will be over-mature and begin to decay, while the top sprouts are still way too small. This makes harvest timing difficult, and mechanical harvest inefficient.

Fertility. A crop of Brussels Sprouts will probably use about 250 - 300 pounds of N, 300+ pounds of K, and 60 pounds of P. In addition, the crop will need around 250 pounds of Sulfate.

Most of this fertility should be provided at the beginning of the season. Start with half of N at planting, side-dress 1/3 after 4 weeks, and spoon feed the remainder through the season as needed.

You should try to grow a tall and strong plant as quickly as possible (so plenty of fertility early on), and the plant should run out of fertility just before harvest.

When the plant runs out of fertility the leaves will turn yellow – the plant will redistribute the nutrients from the leaves into the developing sprouts. So, yellowing and dying leaves are a sign that the plant is making sprouts, and that harvest can begin soon.

If fertility is too high the plant will continue to make leaves, and the leaves will stay green and not fall away from the stem. This means lots of trimming to prepare the sprouts for harvest, and it will also delay the development of the sprouts.

If fertility is too low the plant will fail to thrive, the leaves will turn yellow and the lower sprouts might be OK, but the plant is running out of steam and the top sprouts will not size up.

Jan van der Heide is Northeast Market Manager for Bejo Seeds, Inc. Bejo is a family-owned breeder and producer of quality hybrid vegetable seeds for the professional grower. We plant a wide range of varieties in our demonstration gardens in Geneva, NY every year, and growers are welcome to visit to learn and exchange ideas.

Topping. Removing the top of the stem ("topping") will remove the apical meristem and will make it easier for the top sprouts to develop. Topping will allow top sprouts to size up to catch up with the lower sprouts but be prepared to harvest the sprouts as soon as the top sprouts have the desired size. (Usually 10 – 14 days). The top sprouts will soon become bloomy and will begin to stretch and form new stems.

The modern Brussels Sprout varieties do not need to be topped. Topping will make it possible to harvest the sprouts earlier. Not topping will mean a later harvest, but also more yield (topping removes some of the yield potential).

Why are the lower sprouts so ugly? When the lower sprouts mature too quickly (uneven growth) they will begin to stretch. The sprouts are really side-buds, and overmature sprouts will want to develop into side-shoots. The outer leaves on the sprouts will tear and break as the sprouts begin to stretch and diseases (bacteria, fungi) can move in to cause rot or blackening.

The lower sprouts also often show sign of tip burn, which is often caused by Calcium deficiency. The Calcium deficiency is most often the result of drought stress during early development (similar to Blossom End Rot in tomatoes and peppers) and can be avoided by irrigating during hot and dry weather.

Fertility stress (not enough N) can also lead to weakening of the outer leaves of the sprouts. Weak tissues are an easy target for diseases. Make sure to "read" your crop and be prepared to side-dress some nitrogen to keep the sprouts green and healthy, if needed.

Timing of planting. Growers will be able to choose from multiple varieties with different maturities. An early-maturing variety will need to be harvested on time. Letting sprouts sit in the field for too long just makes a lot of ugly sprouts.

On our demonstration farm in Geneva, NY, we find that transplanting in mid-June gives us the best balance of yield and quality in October. Planting in mid-May results in a lot of deteriorating lower sprouts and planting in mid-July gives lower yields (small sprouts, but very little disease).

For a nice summary and video on growing Brussels Sprouts go to www.bejoseeds.com and scroll down to 2021 Virtual Open House.

DISEASE MANAGEMENT ON TABLE BEETS AND CARROTS

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Table beets and carrots are two important vegetable crops in the Great Lakes and Mid-Atlantic regions, where these root vegetables are grown on large operations for food processors and small to mid-size farms for fresh market sales. Despite differences in scale and production methods, effective disease management in table beets and carrots is essential for all farms to optimize crop stand and ensure high quality roots and foliage throughout the growing season. Beets and carrots may be harvested by top-pulling machinery, which relies on robust foliage. Fresh-market roots are often rejected in the field if foliage is not healthy and green. Proper identification of foliar pathogens is necessary to make optimal pesticide decisions. This summary reviews common beet and carrot diseases in New York and Pennsylvania and highlights recent research from the program of Dr. Sarah Pethybridge at Cornell University.

Best Practices for Disease Management:
Plant pathogens, conducive environmental conditions, and susceptible host crops all play a role in disease development. Alterations to one or more of these factors can reduce the risk of plant disease epidemics. Strategies to consider in the management of beet and carrot diseases include:

- Crop rotation: 3-5 years of non-host crops between beet or carrot plantings is recommended.
- Clean seed: Infested seed lots frequently provide initial inoculum both root and foliar diseases, especially in organic systems where fungicidal seed treatments are not used.
- Residue management: Deep tillage, flaming, or burndown herbicides applied to crop residue can reduce survival of overwintering pathogens.
- Avoiding overhead irrigation: Foliar diseases can be spread within fields by water droplets and splashes; excessive canopy moisture also promotes disease. Good drainage is also important.
- Weed management: Weeds in the Chenopodiaceae family, such as lambsquarters and pigweeds, can serve as alternative hosts for Cercospora leaf spot; other weeds can host the generalist pathogens that cause Alternaria leaf spot and Rhizoctonia root rot.

Diseases of Table Beets:
Cercospora Leaf Spot
Cercospora leaf spot (CLS) is a foliar disease caused by the fungus, *Cercospora beticola*. The primary disease symptoms are tan or gray necrotic lesions with red or purple margins (Figure 1A). Significant CLS epidemics can lead to complete defoliation and rejection of beets for fresh market sales. The diagnostic sign of the pathogen is the presence of pseudostromata in the center of the lesions (Fig. 1B). In NY, over 30% of C. *beticola* isolates were found to have at least moderate resistance to propiconazole (FRAC 3). Alternative products (either in rotation with or apart from FRAC 3 fungicides) are therefore essential. Miravis Prime (pydiflumetofen + fludioxonil (FRAC 7 + 12) has been most effective in NY field trials. Other effective options include Merivon (fluxapyroxad + pyraclostrobin; FRAC 7 + 11), and Luna Tranquility (fluopyram + pyrimethanil; FRAC 7 + 9). Organic control options for CLS include Cueva (copper octanoate; FRAC M 01), Double Nickel LC (*Bacillus amyloliquefaciens* strain D747; FRAC BM 02), and LifeGard (*Bacillus mycoides* isolate

Eric Branch is a Ph.D. candidate in Plant Pathology & Plant-Microbe Biology at Cornell University, where he studies Rhizoctonia solani in table beets with Dr. Sarah Pethybridge. His thesis focuses on management and biology of Rhizoctonia root rot using both conventional strategies and microbiome-based approaches. His enthusiasm for research and Extension began on his family's fruit and vegetable farm in Alexandria, Minnesota. He earned a B.S. degree in Plant Science from the University of Minnesota before starting at Cornell in 2018.

J; FRAC P 06). Recent trials in NY show that tank mixing Double Nickel with Cueva is more effective than the same products applied alone.

Phoma Leaf Spot and Phoma Root Rot

Phoma leaf spot (PLS) and Phoma Root Rot (PRR) are caused by the fungus, Phoma betae. This pathogen can cause damping off and seedling blight, foliar lesions, and lead to misshapen and diseased roots. PLS foliar lesions can be identified by their tan (necrotic tissue) and black (pycnida) concentric rings (Fig. 1C). PRR infections typically begin at the crown of the plant and spread to the rest of the beet root. In humid conditions, the fungus can be observed as white fluffy mycelia around the crown of the root. This disease often impacts table beets in storage. Field trials in NY have shown that fungicides typically applied for CLS control are also effective against Phoma. Conventional products include Tilt/PropiMax (propiconazole; FRAC 3), Miravis Prime (pydiflumetofen + fludioxonil; FRAC 7 + 12). Organic options tested in 2019 and 2021 included both the copper-based products Cueva (copper octanoate; FRAC M1) and Badge X2 (copper oxychloride + copper hydroxide; FRAC M1), and the plant defense activator LifeGard (Bacillus mycoides isolate J; FRAC P 06). LifeGard was more effective than the copper products, but still only provided moderate disease control.

Alternaria Leaf Spot

Alternaria leaf spot (ALS) is caused by several fungi in the genus Alternaria, including A. alternata and A. brassicae. Symptoms of ALS are small, dark spots that develop into larger lesions on beet leaves. Older leaves near the ground are typically affected first. ALS lesions can produce spores in dark brown or black fuzzy patches. Fungicides applied to control CLS and PLS, such as strobilurins (FRAC 11) and demethylation inhibitors (FRAC 3) will likely be effective against ALS, but these fungicides have not been evaluated yet in table beets by the Pethybridge group.

Bacterial Leaf Spot

Bacterial leaf spot (BLS) is caused by bacterium, Pseudomonas syringae pv. aptata. Young table beet plants (less than 6 true leaves) are most vulnerable to BLS, particularly in cooler, damp conditions each spring. BLS symptoms begin with small, water-soaked lesions and can progress to large, irregular, black and tan spots (Fig. 1D). Otherwise healthy beets typically grow out of these symptoms with minimal effects on yield. Careful scouting is necessary to identify BLS in table beets instead of CLS or PLS. Hand lenses can be used to identify fungal structures or spores (PLS, CLS, ALS) or the absence of fungal structures (BLS). Fungicides will not be effective against BLS, but copper products may be necessary when disease pressure is high.

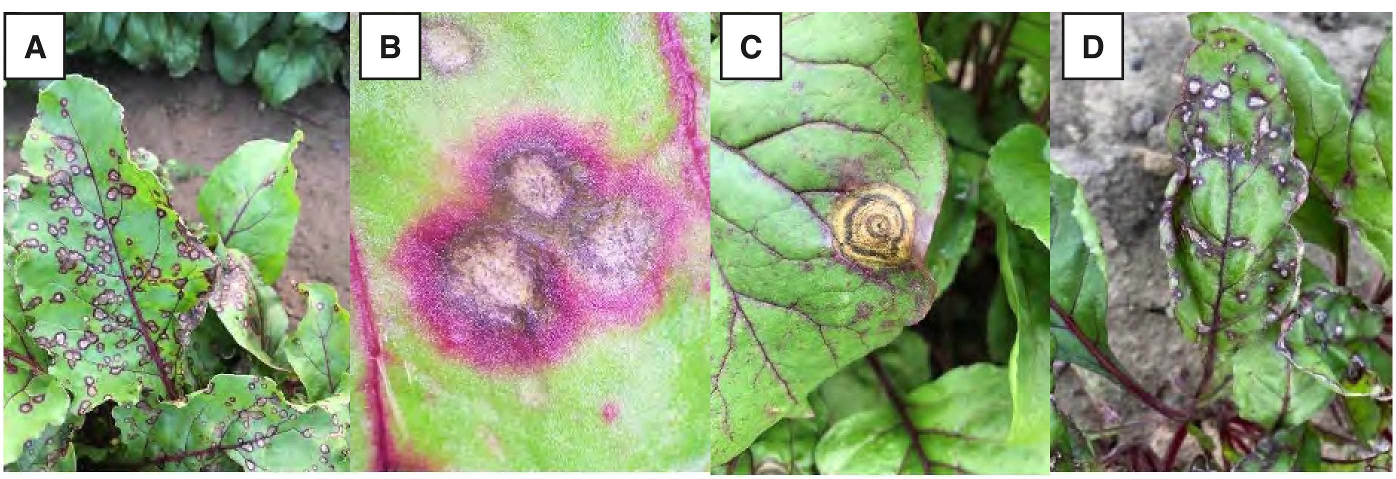

Figure 1. Foliar lesions caused by different pathogens can look similar on table beet leaves. Cercospora leaf spot lesions (A) contain black pin-head structures called pseudostromata (B) that can be observed with a hand lens and are diagnostic of this disease. Phoma leaf spot lesions (C) contain concentric rings of dark fungal structures called pycnidia, which produce spores. Bacterial leaf spot lesions (D) typically affect leaves on younger plants and can be identified in part by the absence of fungal spores. Photo credits: Lori Koenick (A), Sandeep Sharma, (B), Pratibha Sharma (C); and Sarah Pethybridge (D).

Rhizoctonia Root Rot and Damping Off

Rhizoctonia diseases of table beet are caused by the fungus, *Rhizoctonia solani*. This soilborne pathogen infects beet seeds and seedlings, causing damping off and reducing plant populations. Infections in mature roots results in Rhizoctonia root rot (RRR). Typical RRR symptoms include black lesions, cracking, and misshapen roots. Leaf petioles can also be affected, characterized by black lesions near the crown of the beet. RRR symptoms may be confused with boron deficiency. R. *solani* can survive for long periods in soil as sclerotia and on plant residue. Alternative hosts include legumes and vegetable crops, making effective crop rotation difficult. Field and greenhouse trials in NY from 2019, 2020, and 2021 all show that in-furrow fungicides are most effective at controlling Rhizoctonia damping off and RRR. Additional application provided only marginal benefits, if any. Quadris (azoxystrobin; FRAC 11) provides good control. Products with additional FRAC groups provide similar, not better, disease control. A recent field trial (2021) did not show a reduction in damping off and RRR from any organic products tested, including Double Nickel, LifeGard, and a copper-zinc combination product.

Diseases of Carrots:

Cercospora Leaf Blight

Cercospora leaf blight of carrot is cause by the fungus, *Cercospora carotae*. Symptoms of this disease are circular tan or brown necrotic lesions. Initial lesions have a chlorotic halo. As stem lesions expand, defoliation can occur. Younger leaves are more susceptible to infection than older leaves. Preventative fungicides in NY are usually successful at controlling both Cercospora and Alternaria leaf blights in carrots. Conventional fungicide rotations for may include products in FRAC 7 and FRAC 11, such as penthiopyrad (FRAC 7) and strobilurins (FRAC 11).

Alternaria Leaf Blight

Alternaria leaf blight is caused by the fungus, *Alternaria dauci*. Symptoms of Alternaria leaf blight include dark, irregularly-shaped lesions, more commonly seen on older leaves than younger leaves. Lesions caused by Alternaria leaf blight are darker in color than Cercospora infections and can often lead to a burned or scorched appearance. In addition to products for Cercospora leaf blight control, conventional fungicides containing iprodione (FRAC 2), difenoconazole (FRAC 3), cyprodinil (FRAC 9), and fludioxonil (FRAC 12) may be effective. These additional fungicides do not typically provide equal control of Cercospora and Alternaria leaf blights in carrots.

Storage rots

Root rot can occur during the end of the growing season and cause root decay during the winter storage period. Common fungal culprits include white mold (*Sclerotinia sclerotiorum*) and gray mold (*Botrytis cinerea*). These pathogens are generalists and persist in many other vegetable crops. Secondary infections of soft rot bacteria can also occur. Cultural preventative measures are important, including disease control during rotational crops, residue management, and sanitation of harvest and storage facilities. Wet conditions remain the most important risk factor for late-season root rots and decay. Both insect damage and mechanical damage are also risk factors for root rot in carrots. Post-harvest dip treatments are available and can be effective at reducing fungal growth during storage.

Rhexocercosporidium carotae was first reported in NY in 2015 as a pathogen causing root decay in cold storage. No symptoms were observed at harvest, but large, black, irregularly-shaped lesions developed several months later (Fig. 2).

Figure 2. Black lesions caused by *Rhexocercosporidium carotae.*

NEW TACTICS AND TOOLS FOR CONTROLLING POTATO BEETLES AND WIREWORMS IN POTATOES

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Colorado potato beetle

Anyone who has grown potatoes in the mid-Atlantic U.S. is probably all too familiar with the conspicuous Colorado potato beetle (CPB) and its voracious red larvae that can significantly defoliate plants resulting in substantial yield loss. Beetles overwinter in the soil usually where potatoes were grown the previous year. They emerge in the spring and immediately walk to newly emerged potato plants, where they mate and deposit their bright yellow egg masses. For commercial potato growers, at-planting or seed-treatment applications of neonicotinoid insecticides such as Admire Pro (or other imidacloprid 2F products), Platinum, Belay, Scorpion, Venom, or Brigadier have been widely used by many as a cornerstone of their insect pest management programs. These insecticides have a low mammalian toxicity and work well as a systemic insecticide that is taken up by the roots and moved to above-ground plant tissue to kill certain insects that feed on leaf tissue such as CPB, potato leafhoppers, flea beetles, and aphids. Unfortunately, wide-scale indiscriminate use of neonicotinoids globally has brought about various levels of concern and regulatory action, which has caused some growers to seek alternative insecticide to the neonicotinoids. In addition, insecticide resistance to neonicotinoids has appeared in some populations of CPB from the northeastern, mid-Atlantic, and Midwestern U.S. Managing neonicotinoid resistance in CPB through integrated pest management practices and rotation of insecticide active ingredients is key to sustaining the long-term efficacy of these compounds for potato producers.

I invite you to read the following article in the open-access Journal of Integrated Pest Management:

> Huseth, A.S., R.L. Groves, S.A. Chapman, A. Alyokhin, T.P. Kuhar, I.V. Macrae, Z. Szendrei, and B.A. Nault. 2014. Managing Colorado Potato Beetle Insecticide Resistance: New Tools and Strategies for the Next Decade of Pest Control in Potato. Journal of Integrated Pest Management 5(4): 2014; DOI: http://dx.doi.org/10.1603/IPM14009

Entomologists like myself are continuously evaluating new insecticides for potential use in potatoes and other crops. Please see Fig. 1. for a summary of foliar insecticide options for Colorado potato beetle; insecticides are grouped by their mode of action.

In 2021, we evaluated the efficacy of most of at-planting insecticides registered for potato beetle control. The trial was conducted in Painter, VA. Results are shown in Table 1. The neonicotinoids Admire Pro, Platinum 75SG, Wrangler, and Cruiser Maxx seed treatment as well as the diamide insecticide Verimark all provided excellent systemic control of CPB larvae up to 60 days after planting. Sivanto HL provided very good, but slightly less residual control of CPB. All treatments except Sivanto resulted in significantly higher yields than the untreated control.

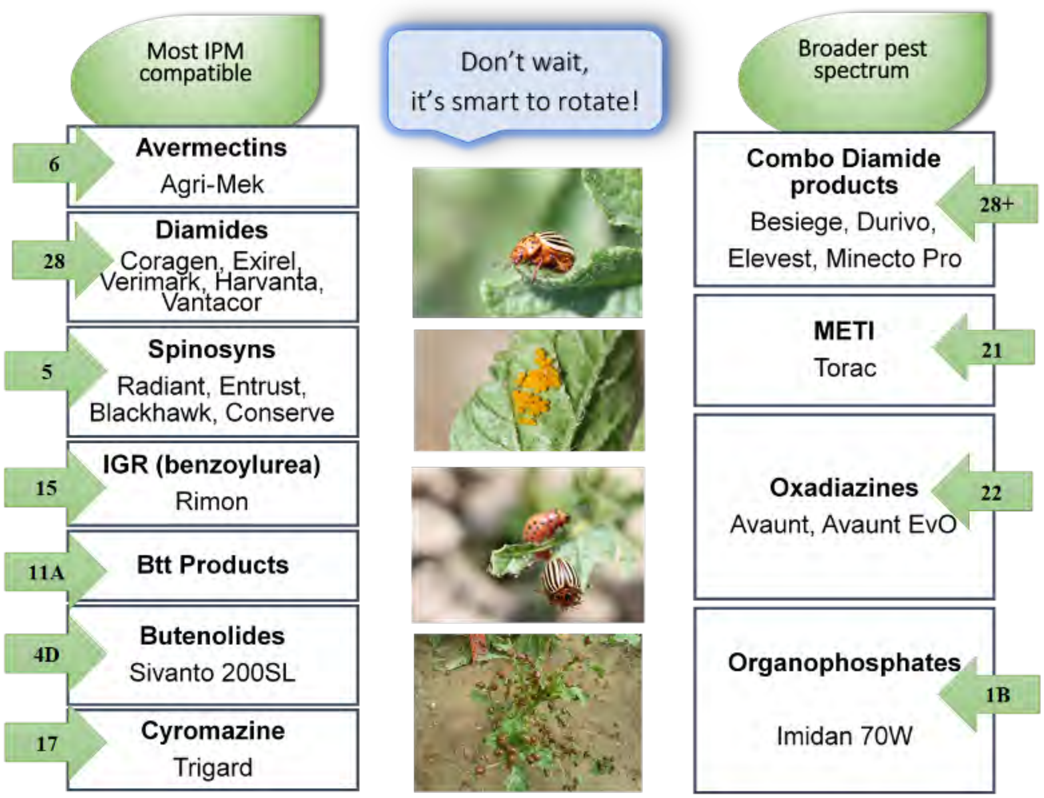
Tom Kuhar is a Professor in the Department of Entomology at Virginia Tech. He has been a regular speaker at the MAFVC since the mid-2000s. Dr. Kuhar's research focuses on the integrated pest management of insect pests of potato and vegetable crops. He has trained over 30 graduate students and has published over 130 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.

Table 1. Summary of efficacy of soil applied labeled insecticides for the control of Colorado potato beetles in potatoes; ESAREC, Painter, VA 2021

		Mean no. Colorado potato beetles / 10 stems						
		18-May (49 DAP)	25-May (56 DAP)		2-Jun (62 DAP)		% defoliation 1 Jun	Total Yield (in cwt/A)
Treatment	Rate / acre	small larvae	small larvae	large larvae	small larvae	large larvae		
Untreated check		46.8 a	55.8 a	95.3 a	49.5 ab	46.8 a	48.8 a	88.6 b
Admire Pro	8.7 fl. oz	0.0 b	5.5 bc	0.0 b	5.8 b	2.0 bc	0.0 b	167.3 a
Platinum 75SG	2.67 oz	0.0 b	1.3 bc	0.0 b	0.0 d	0.0 c	0.0 b	165.2 a
Sivanto HL	14 fl. oz	3.8 b	13.3 b	7.3 b	69.8 a	17.8 b	12.5 b	127.4 b
Verimark	13.5 fl. oz	0.0 b	1.3 bc	0.3 b	4.3 d	0.8 c	0.0 b	169.2 a
Wrangler	9.2 fl. oz	0.0 b	1.8 bc	0.5 b	15.0 cd	5.8 bc	2.5 b	172.4 a
Cruiser Maxx ST	0.31 oz / cwt	0.0 b	0.0 c	0.5 b	36.0 bc	1.0 c	3.5 b	173.2 a
P-value from Anova		<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<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).

Fig. 1. Colorado Potato Beetle Foliar Insecticide Menu for Potato Growers. Insecticides are grouped by IRAC class number based on their mode of action (MOA).



Also in 2021, we evaluated most of the labeled non-neonicotinoid foliar insecticides registered on potatoes. The trial was conducted in Painter, VA and two foliar applications were made 21 and 28 May. Treatments included: Sivanto (with similar MOA as neonicotinoids), the diamide products Harvanta, Exirel, Coragen, Vantacor, and Besiege; the spinosyn insecticides Blackhawk 36WG, Radiant, and Delegate; Torac, a mitochondrial poison; Agri-Mek (abamectin), the insect growth regulator Trigard 75WP; and Minecto Pro (a combo insecticide with the diamide cyantraniliprole + abamectin). All insecticide treatments provided excellent control of CPB larvae (Table 2).

Table 2. Numbers of CPB larvae per 10 potato stems after foliar applications of different labeled insecticides on potatoes in Painter, VA 2021. Sprays made 21 and 28 May.

Treatment	Rate / acre	24-May (3 DAT)		2-Jun (6 DAT2)	
		Small larvae	Large larvae	Small larvae	Large larvae
Untreated check		54.3 a	96.0 a	63.0 a	100.8 a
Sivanto Prime	14 fl oz	3.3 b	0.0 c	6.5 b	2.0 b
Sivanto HL	7 fl oz	5.0 b	0.8 c	8.3 b	3.5 b
Harvanta	16.4 fl oz	2.0 b	0.0 c	0.0 b	0.0 b
Exirel	13.5 fl oz	9.8 b	0.0 c	0.0 b	0.0 b
Coragen	7.5 fl oz	2.0 b	0.0 c	0.0 b	0.0 b
Vantacor	7 fl oz	4.0 b	0.0 c	0.3 b	0.0 b
Besiege	9 fl oz	1.3 b	0.0 c	0.0 b	0.0 b
Torac + PBO	14 fl oz	0.0 b	0.0 c	0.3 b	0.0 b
Agri-Mek	3.5 fl oz	9.3 b	1.3 c	5.0 b	3.8 b
Blackhawk 36WG	3.3 oz	0.5 b	0.3 c	0.0 b	0.0 b
Radiant	8 fl oz	0.0 b	0.0 c	0.0 b	1.0 b
Delegate	4 oz	5.5 b	2.0 c	0.0 b	0.0 b
Trigard 75WP	5.32 fl oz	46.0 a	46.0 b	9.8 b	6.0 b
Minecto Pro	10 fl oz	7.8 b	0.0 c	0.0 b	0.0 b

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).

Wireworms

Wireworms are the subterranean larval stage of click beetles, and in the Mid-Atlantic U.S., the cornfield wireworm, *Melanotus communis*, is the predominant species attacking potatoes. 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 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 Insecticides that have provided the best reduction in wireworm damage to potatoes include the older organophosphates Mocap or Thimet, Regent (fipronil), and the pyrethroid Capture LFR (bifenthrin). It should also be noted that the neonicotinoids applied at-planting for other pests like potato beetles also will reduce wireworm damage by at least 50%. One post-planting option for growers is to apply the foliar product, Movento (spirotetramat) at flowering.

It has been many years since we've seen a new insecticide for wireworms. In 2021, we evaluated a brand-new insecticide from Syngenta called PLINAZOLIN® (active ingredient = isocycloseram), formerly referred to as ISM-555 during development. It performed as well as the standard Capture LFR at reducing tuber damage (Table 3). PLINAZOLIN® should be formulated into commercial products soon.

Table 3. Summary of efficacy of PLINAZOLIN® soil applied for the control of wireworms in potatoes; Abingdon, VA 2021. Note, all treatments included Vibrance Ultra seed treatment at 10g AI/100 kg seed.

Treatment	Rate	Number of tubers/50 with wireworm holes
Control	-	30.8 a
PLINAZOLIN®	3.43 fl oz/A	13.3 b
PLINAZOLIN®	5.15 fl oz/A	17.8 b
Capture LFR	21.3 fl oz/A	11.5 b

SCOUTING YOUR POTATO FIELDS – WHAT TO LOOK FOR AND WHEN

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Field scouting is one of the most economical and efficient ways to find issues with a crop and work to prescribe the best management action to counter those problems. When dealing with high dollar vegetable crops, such as potatoes, reducing input costs and increasing yield and quality is crucial. Any potato grower can adopt basic scouting principals and modify them to their own fields and practices to make every season successful.

Scouting Methods

The sole purpose of scouting is to efficiently get a summary of how a particular field or area is doing at a particular moment in the season. From this summary, you can develop management actions (such as spraying certain pesticides) to deal with problems you know are actually present. This snapshot should be a good representation of all the variation across the field. Therefore, you have to actually walk through the majority of the field and randomly sample plants. Several methods exist for random walking patterns, including M, V, and S patterns. My preferred method for potato scouting is a modified S pattern: start each field along the headlands, and primarily use the field's spray tracks to walk through the field, snaking out of that row at random points throughout the field. Combing through 10 plants in at least 5 areas of the field is usually sufficient sampling for insect and disease pressure. Depending on your total acreage, you should aim to sample at least half on a weekly basis.

Early Season Scouting

The first few weeks after planting serve as the perfect time to diagnose planter issues and emergence issues. While it is too late for the current season, remedies can be thought of to correct those problems for future years. Digging up sections of row allow you to analyze skips, seed piece rot, disease issues like Rhizoctonia, and root architecture problems. Once the first shoots emerge, now is the time to look for leafhoppers that can transmit hopper burn after prolonged feeding. Flea beetle infestations can also cause vigor issues, although plants are typically able to grow out of a shorter duration of feeding. You may also notice the first generation of Colorado Potato Beetles (CPB): a few adults may be present along with egg masses on the underside of leaves. Generally speaking, if you use a systemic insecticide on the seed piece, insect issues do not pose a threat in these first couple weeks of the season. This is also the best time to look for weed escapes if you do one pass hilling. Post emergent herbicides work the best on weeds not much past the white thread stage.

Tuber Initiation

Around this time is when any remaining residual insecticide from seed treatment programs has usually worn off (if not sooner). Paying closer attention to insect issues is a must – leaf and grass hopper issues along field edges can quickly turn into whole field problems. While economic thresholds for spraying insecticides should be fine-tuned at the farm level, a good level to start for leaf hoppers is 6-10 per 50 plants (both nymphs and adults). The same goes for CPB: systemics are too diluted in the plant canopy to kill CPB at this point as well. Spraying a good knock down insecticide aimed when populations are just past egg hatch (but not at adult size) might give you season long control. Once flowers appear, now is the time to look for thrips; knocking flower clusters against a white clipboard is a quick method to estimate populations. 100 thrips per 50 plants in a non-irrigated setting is a good spray threshold to start at.

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Knowing row closure allows you to assess when you want to start fungicidal sprays. It is not uncommon to start finding the beginning signs of botrytis and early blight/Alternaria. If you plan on treating for early blight, sprays should be aimed for 80% row closure. Digging up a few hills per field during this time will show you average tuber set and size. Certain fungicides, such as Ridomil Gold, should be applied when tubers are nickel sized. Row closure and weather conditions will indicate when it is time to start preventative late blight sprays.

While scouting, you can easily collect petiole samples as well to see what in-plant nutrient levels are. Be sure to only compare field samples collected at the same time and at the same plant maturity level.

Tuber Bulking

By this time in the season, your scouting goal is to keep the plants as healthy and vigorous as you can. Taking notice of changing insect pressure or disease pressure can have huge impacts a week or two later. Some types of insects may have huge swings in populations: southern storms may bring lots of leaf hoppers or the first few caterpillar types that might multiply exponentially. Seeing a few caterpillars or armyworms at the beginning of the month may warrant a spray, or at the very least, give insight to a future outbreak a few weeks later. Finding products that take out several insects at a time may confer a cost savings. Spotting above average levels of beneficial insects might allow you to skip an insecticide treatment altogether.

Weekly scouting will allow you to pinpoint the peak growth of the crop and the start of plant decline and subsequent senescence. Starting to check tuber size distribution is important at this time.

End of Season Scouting

Based on your findings of tuber size distribution, you can start to plan your first vine desiccation spray (if necessary). Plants in the late tuber bulking stage influence the thresholds for insecticides; if you plan on desiccating the crop in 1-2 weeks, there is less economic incentive to kill certain types of insects like leaf hoppers. Heavy feeders, such as armyworms and high populations of CPB can still pose a threat, especially if there are other potato fields in the area that are further away from vine desiccation. It is important to maintain preventative fungicide treatments up to and including vine desiccation. If you think the crop needs a second desiccation spray, it is important to wait 1.5 weeks before taking a second look.

Final potato scouting of the season consists of making yield and quality assessments for areas of the field.

Year End Review

At the end of harvest season, good record keeping can allow you to trace back good and not so good decisions made in-season based on your final yield and quality. Utilizing an electronic method of note taking for weekly scouting has many benefits, including the ability to quickly search for key words and filtering to specific fields/areas of concern. Pairing this with electronic spray records can serve as a good historical guide for future growing seasons. Having electronic versions of key documents allows for easy on-farm discussion and distribution to other farm personnel and extension agents.

HIGH TUNNEL CROP ROTATION
TOMATOES, CUCUMBERS AND STRAWBERRIES
A FARMER'S VIEWPOINT

Nathaniel Burkholder, Shore Lane Vegetable Farm

The primary benefits of having high tunnels include:

- No rain and wind on plants make for a nicer product.
- There is less weed and disease pressure.
- The earlier product brings a better price.
- We are better able to double crop.

Drawbacks to having high tunnels include:

- Windy days.
- More greenhouse pests.
- Plastic upkeep and re-covering each spring.
- The rotation is often too tight.

Four season tunnels vs three season tunnels

Four season tunnel is built to withstand snow load and therefore does not need to be uncovered for the winter. With some heat and/or row covers, a winter crop is possible. Insect and diseases can overwinter better.

The benefits of having a three season tunnel are that they don't cost as much to build, the rain, snow and thaw help to condition the soil, and the exposure to the elements knocks back most of the pests.

There will be topics on our farm experience with:

- Early and late cucumbers
- Early season tomatoes with red beets
- Strawberries
- String beans, zucchini and more that we have tried

Nathaniel Burkholder from Short Lane Vegetable Farm in Fleetwood, PA has been growing 50 acres of cole crops, sweet corn, strawberries, cucumbers and zuchinnis on the family farm since 2009. He and his family also grow various crops in 1 ½ acres of high tunnels. He and his wife, Rebecca, are thankful for the opportunity to raise their four young children on a farm and be able to work together as a family.

IMPROVING TOMATO AND PEPPER FRUIT QUALITY

Steve Bogash, Territory Business Manager NE, Marrone Bio Innovations, Inc.

There are seven variables in creating high quality tomatoes and peppers: variety selection, field / tunnel crop rotation, crop nutrition, disease and pest management, heat / sunscald management, time of year / light levels, and post-harvest handling. How we manage these variables directly impacts the size of our harvest and the grade of that produce. At least seven are what the author can come up with at this writing.

-**Variety selection:** Crop genetics play a major role in the final quality and brix levels of fruits and vegetables. This is not a discussion of heirloom vs. hybrid or even a GE / GMO argument. Based on years of tomato, and bell pepper variety trials, there are simply varieties that consistently work better under local and regional growing conditions and have the inherent genetics to achieve higher brix levels and greater yields of marketable fruit. Since this meeting is taking place in the Mid-Atlantic, we will keep the discussion(s) to our climate and weather. The highly variable conditions under which we grow the crops in question greatly limits the varieties that produce sustainable harvests of marketable fruit. High tunnels and greenhouses open the door to different varieties as compared to field-grown, but controlling humidity in the middle of our typical summers is largely outside of high tunnel managers' control. Hot set type tomatoes will create fruit at temperatures that are few degrees warmer than other varieties.

-**Field rotation:** Rotating between vegetable families is one of the easiest ways to reduce diseases, avoid (some) soil dwelling or overwintering insect pests, and improve nutrient availability. This works especially well when incorporating cover crop strategies into your rotation scheme. This is one of the greatest challenges for high tunnel growers as the soil under cover is often the most valuable on a farm. Oddly, growers will punish this same soil with little to no crop rotation or even soil building due to the price of tomatoes early in the season. Reconsider this decision for a longer sustainable harvest by rotating tunnels out of production for a year of cover cropping very 3-4 years. The most effective solution that can also reduce accumulated soluble salts is to move some of your high tunnels every 3-4 years or when you need to replace the glazing. This break in production and exposure to rain and snow can reduce disease inoculum, reduce excess soluble salts, and increase organic matter.

-**Crop nutrition:** Managing crop nutrition through preplant, fertigated and foliarly applied nutrients is the most direct path to improving the flavor and brix levels in fruit. High N levels can create soft fruit and will compete with K in plant tissue incorporation. The relative balance between the plant cations K, Ca, and Mg has a major impact on fruit firmness, flavor and brix levels. Having all of your nutrients prior to planting in sufficient amounts and in balance with each other makes in-season nutrient management much simpler. Same goes for soil and water pH. Both tomatoes and peppers prefer soil and irrigation water that is slightly acidic (6.2-6.5). Too high or too low soil or water pH makes it extra challenging to grow a great crop. In areas with limestone-based soils, the addition of a regularly metered dose of acid is required to grow the best tomatoes and peppers.

-**Time of year / Light levels:** High tunnel growing is a balance between planting as early as possible in order to reap the rewards of higher returns on fruit and the costs incurred in trying to plant so early. Heating costs have long been the major consideration as earlier planting dates will drive heating costs higher. Not enough growers consider how early season light levels will impact their production. We will consider supplemental lighting to be a greenhouse input except for those used o produce early transplants. The shortest day of the year is December 22. We gain 3 minutes a day of daylight from that time, but much of the light gain from daylength is lost in late February and early March to low sun angles and typical cloudy winter weather. Without bright sunny days, plants just sit with little growth costing growers heating inputs. The number one call that the author receives from tomato growers in March and April is: "Why are my tomato / pepper plants not growing"? Growers cannot heat their way to plant growth when the days are short and the weather cloudy. Generally, little production earliness is lost when a grower plants in late March or early April due to insufficient light earlier.

-**Heat / Sunscald management:** It is a simple fact that our growing seasons are getting hotter. This stresses out tomatoes and peppers to the point where we often see aborted fruit and multiple abiotic fruit maladies. Pepper growers should install 30-40% shade fabric by Mid-June. The addition of a spray-applied, non-film causing, heat stress manager like Haven® has proven to increase fruit quality and quantity in multiple trials. Tomato growers experience less cracking, blossom end rot, and yellow shoulders when Haven® is applied every two weeks from initial fruit set through harvest. Pepper growers will see increased yields and reduced sunscald injury.

-Pest management: The best pest management is a proactive activity. Begin preventative disease, insect and mite management at transplanting. The application of a soil inoculant such as those that contain Trichoderma harzianum, Streptomyces lydicus, and various combinations of beneficial bacteria at planting has proven to be an excellent and inexpensive method of preventing many soil-borne diseases. Many of these products also assist in the uptake of nutrients. Begin applying pesticides for the prevention of fungal and bacterial diseases at transplanting. The same goes for insect and mite prevention. Green Peach Aphids get active as cool as 50F and are often the first insect growers needs to manage. By the time a grower finds the first Western flower thrips, there are usually many, so scout often, apply preventatives regularly and be prepared to adjust programs and strategies as the season requires. Ask the author for his annual 'Cheat Sheet' with multiple recommendations for prevention and control strategies. These recommendations are revised annually based on lessons learned and winter meeting updates.

-Post Harvest handling: How fruit are handled during and after harvest has another major impact on fruit quality. Tomatoes and cucumbers are very tender, so require great care during harvest and packing. Some fruit give off high levels of ethylene which can degrade other fruit in the same packing area, while others are highly sensitive to ethylene. Tomatoes taste awful after storage below 50F while bell peppers can handle temperatures down to 34F for prolonged storage. Consider a PAA (peroxyacetic acid / JetAg 5) application the evening before harvesting to reduce surface inoculum.

Tomatoes and Bell Peppers

One of the greatest challenges in growing tomatoes and bell peppers in an intensive production system is keeping up with the plants high consumption of potassium during fruit production. Past recommendations have been based around beginning to increase potassium application along with the first tissue test at the onset of flowering. This often results in our chasing potassium levels over 2-4 weeks in order to get them above 3% by dry matter. Very often some of the first mature fruit are yellow shouldered. The heavy consumption of potassium actually starts about 2 weeks prior to when the first flowers are visible. The concept of 'banking' potassium or applying extra a bit earlier seems indicated to reduce packing house losses and maximize flavor.

Before you start applying extra potassium, your irrigation / fertigation solution needs to be at the correct pH. Tomatoes and peppers optimally extract nutrients at a pH of 6.2-6.5. For growers pulling irrigation water from limestone aquifers, this will probably mean the addition of acid on a constant basis. Get your water tested at a laboratory for pH and alkalinity expressed as ppm bicarbonate. Since the pH scale is logarithmic, each 1 point on the scale is a 10X difference in pH. A two point difference is 10 x 10 or 100X. This means that small variances from the ideal pH of 6.2-6.5 can result in major nutrient deficiencies. Most growers use either sulfuric acid or citric acid. Organic growers can use citric acid. Use the online alkalinity calculator to get your sulfuric, phosphoric, and nitric acid concentrations: http://extension.unh.edu/Agric/AGGHFL/alk_calc.cfm. Be sure to follow all directions on the calculator and pay careful attention to the pull down menus on the input side to get the correct recommendations. There is no calculator for using citric acid. However, Tom McCarty, PSU Water Quality Educator Retired, and I did extensive experiments on water samples collected throughout Central and SE PA and found that 9 oz. of powdered citric acid consistently reduced the pH of 100 gallons of irrigation water by 1 full point. Growers using acids to modify irrigation water must regularly use a two-point, calibrated digital pH meter to adjust their water pH as injected nutrients, weather events, and for surface sources time of day all impact the pH in the irrigation flow.

Since we need to start the application of higher levels of potassium earlier than flowering to bank some and have high enough levels for the first fruit, tissue analysis should start as soon as your plants are large enough to collect full sized mature leaves from and not cripple your plants. Make the change to a higher potassium ratio fertilizer at about 4 weeks after transplanting. Start a weekly application of a foliar potassium at that same time. Be sure your fertilizer is compatible with foliar application. Organic growers will use potassium sulfate for this purpose. Good quality, highly soluble potassium sulfate at 1-2T / gallon applied foliarly just to the point of wetness works well for this application.

Growing great tomatoes and bell peppers that are full flavored and have low losses in the packing house requires keeping tissue potassium levels above 3%. From before the first blossoms to the last harvest, tomato plants (and peppers as well) require substantial addition of potassium to produce the most flavor and prevent yellow shoulders / gray wall. Although we need to consider every nutrient level, those most important to packout are:

1) Tissue N levels should be at about 4% as fruit are developing. Higher levels can create soft fruit, more foliage, and fewer fruit. Higher N levels will also create more yellow shouldered fruit.

2) Tissue K levels need to be above 3% for tomatoes and peppers to produce the highest quality fruit and to keep creating new blossoms.

3) Ideally Ca should be at about 3% and Mg at 0.8-1%. This prevents cracking and produces fruit that are tough enough for packing and shipping. In retrospect, although I've always recommended bi-weekly tissue testing to growers due to the cost of the tests, I now recommend weekly sampling that starts as early as the plants can handle the cut.

If you plowed down 80% of your soil test recommended potassium, calcium and magnesium when getting your soil ready and work to keep these levels at their optimum values, you should be able to increase yields and reduce packing house losses.

USING BENEFICIAL INSECTS AND MITES TO MANAGE APHIDS, SPIDER MITES, AND THRIPS

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Greenhouse biological control all started in greenhouse tomatoes, at first in whitefly control using 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 control many pests in vegetables, including fungus gnats, aphids, thrips, whiteflies, and spider mites. Today, we will concentrate on aphids, spider mites and thrips.Start Clean, Stay CleanBiocontrols 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 your cropis following so that you do not inoculate your new young plants with pests first thing. In recent years, the upsurge in winter greens in high tunnels can produce many overwintering aphids. If these transfer over to your spring crops, they will be overrun with aphids months before normal. If you have winter greens, do not let the aphid populations build up and infest your spring crops!Similarly, be sure that your seedlings are started in a clean area that is free of aphids, thrips or spider mites.In order to keep pests at bay, ask your supplier to help you create a release schedule to start 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 attractiveto 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 grow!Natural Enemies for Aphid ControlNatural Enemies for Aphid ControlIdentifying your aphid species makes a big difference if you are using aphid parasites. There are four parasitic wasps used in high tunnels. Aphidius colemani attacks melon aphid and green peach aphid, but not potato aphid, also a common pest in high tunnels. The more pricey Aphelinus abdominalis and Aphidius ervi attack potato aphid. Aphidius matricariae is used for the pink form of the green peach aphid. It is important to repeat parasite releases at least once a week after the first release in order to create overlapping generations of adults. Green peach aphid is a moderately large green to pink aphid that is often found on plants 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 ervi because the cereal aphids are too small to be hosts for these large aphids. In the case of potato aphid, IPM Laboratories has developed 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 purchase the mixture of aphid parasite species. This option is more pricey, because it is likely that some of the species that you bring in will not find aphid hosts, but it will save you the time and trouble of aphid ID.Another way to get around the aphid identification question is to release the predators like lacewing larvae or the aphid midge, Aphidoletes aphidimyza. The predators kill many species of aphids. The lacewing larvae must be applied to the plants that need aphid control, whereas the aphid midge will fly to those plants on its own and lay eggs where they find the aphids. These eggs 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 overlap-

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ping generations. When day length 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. Aphidoletes is not a good choice in low temperatures as they are not active below 60º F.There are a few aphids on winter greens that we can't control with commercial aphid parasites. These include the cabbage aphid and the turnip aphid. The best choice for these are lacewing larvae.Natural Enemies for Thrips ControlNatural Enemies for Thrips ControlNeoseiulus cucumeris, commonly called Cucumeris, is a predatory mite used for thrips control in tomatoes, peppers and cut flowers. 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 foliage, they must be reapplied every 2 weeks for the loose material, or every 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, but is excellent for controlling thrips on peppers, where it colonizes the flowers and reproduces on its own after one or 2 releases.Natural Enemies for Spider Mite ControlThe 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. Instead, 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 predator 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 plantsare especially helpful to time the Feltiella release, and serve as a comfortable habitat for them to colonize.Another predatory mite, Neoseiulus fallacis is used in brambles and strawberries for spider mite control. This species is native to the Northeast US, and can overwinter here. This should be released at the first sign of spider mites in brambles or strawberries.Pesticide compatibilityIf 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 of beneficial, 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 thoughtsTo 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 create 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.

INNOVATIVE CROPS FOR SMALL FARMS

Alternative Fruit Crops for Mid-Atlantic Region

Andrew G. Ristvey, Ph.D.
University of Maryland Extension Specialist, Commercial Horticulture

Nationally, the age range of farmers is between 55 and 65 (NASS Data). One of the greatest challenges for transitioning farms to younger owners is land accessibility. Three-quarters of new farmers in the 2017 survey were not inheriting land since they do not come from traditional family farms. Land prices have doubled throughout the country over the past 10 years making land increasingly difficult for new farmers to find and afford. Alternatively, young urban farmers are finding spaces inside urban areas, either reclaimed land or on rooftops. Farmers need to make the most profit off of smaller land parcels. This is where high-value, specialty crops have a place in U.S. agriculture.

University of Maryland Extension has developed an alternative crop program to assist farmers, both experienced and new, to find new high-value, alternative specialty crops and understand fundamentals of plant production to increase farm efficiency, productivity and profitability on smaller areas of land. A few of these plants, being grown at University of Maryland's Wye Research and Education Center (WyeREC) in Queenstown MD, are featured in this program talk along with ideas on their cultural management.

The fruit-crop *Aronia mitchurinii* is an intergeneric hybrid of *Aronia malanocarpa*, the Eastern U.S. native plant, black chokeberry. This crop has been extensively cultivated in Eastern Europe for over 40 years. For the past 15 years, the fruit has been cultivated primarily in Mid-Western states like Iowa, Nebraska and Wisconsin. The fruit has a very high concentration phytochemicals which include polyphenols, flavonoids and anthocyanins, which are touted to be potent antioxidants. This gives Aronia a marketable trait as a specialty crop. Some of these antioxidants give the fruit an astringent flavor, described by some like a dry, red wine. The fruit are dark purple pomes, about the size of a blueberry, and have a relatively thick skin like an apple. Plants flower in late April to mid-May depending on local climate. Flowers are apomictic which means they can self-pollinate with the help of pollinators like native bees, which have been observed at WyeREC. The fruit develops over the summer and is harvested between mid-August and early September. At harvest, the fruit can have a soluble sugar (brix) content between 15 and 18. The plants can yield up to and over 15 lb of fruit within 4 years, with some of the plants yielding over 30 pounds. The crop is very hardy and very resistant to the typical pests and diseases that plague pome and drupe crops in the rose family. However, they are still not without problems. Japanese beetle predation is the most critical and some IPM strategy is necessary to minimize leaf canopy damage. Another major introduced pest is Japanese Maple Scale. A very active IPM program is required to control this pest in both organic and non-organic production. The crop is also susceptible to apple scab (Fusicladium) a prevalent disease for Aronia on the Eastern Shore of Maryland. The research at the University of Maryland has focused on nitrogen nutrition and its effect on yield and fruit quality including phytochemical content.

Haskap or honeyberry (*Lonicera caerulea* L.) is a fruit in the honeysuckle family. The species is native to Northeastern Asia (Japan) and Siberia. The earliest record of introduced plants to North American is around 2000 (Thompson, 2006). The plant has been studied by a number of fruit-production researchers in Northwestern U.S and Canadian provinces of Saskatchewan and British Columbia, who are breeding this crop for increased productivity and commercial cultivation. Many nurseries in northern states sell various cultivars. The University of Maryland received 4 selections from researcher and breeder, Dr. Maxine Thompson in 2016. Since that time, crop observations and yield measurements have been underway. Plants do not self-fertilize, so varieties with similar flowering times are necessary to be planted together for full fruit production. Recommendations for compatible cultivars is available in the trade. The pollinators are primarily bumblebees because of their tolerance to colder temperatures when the flowers tend to bloom. In Maryland (Eastern Shore), all selections from Dr. Thompson bloom around mid-April. The fruit ripens quickly and is ready for harvest in late May. The fruit are dark blue (like blueberry), and very soft at harvest. Care must be taken not to damage them when picking. New selections from Canada are creating hardier fruit for mechanical harvesting. Since planting at WyeREC, the haskap plants have remained small; no more than 20 inches high and 12 inches in width. This is contrary to reports of bushes reaching 6 feet high after a few years after establishment. Since they are native to northern boreal climates, the heat and humidity of Maryland's Eastern shore may reduce their summer vegetative growth, even with irrigation. The fruit from the selections at WyeREC have had a sour, plum-like flavor. Many of the advertisements in nursery catalogs cite sweet flavors. The juice from the fruit had an average pH of 2.7 and a Brix of 15%. Reports from nurseries and breeders state that plants can bare up to 10 lb fruit per plant. Harvests at WyeREC have not yielded more than ½ lb per plant. No pests were observed on the plants and fruit, and while powdery mildew is one main concern, no infections were noted in Maryland. Birds are mostly likely the biggest problem. Like *Aronia*, haskap has very high antioxidant content, and it includes several of the same class of phytochemicals. More varieties will be trialed in the coming years, however at this time, it is recommended that growers in southern regions of the Mid-Atlantic that are interested in starting haskap production experiment with a small number of a few different varieties that may do well in warmer climates.

Ground cherry or husk cherry (*Physalis grisea or P. pruinosa*) are two of many species of *Physalis* in the tomato (Solanaceae) family. Like haskap or Aronia, this fruit has been identified as another one with valuable phytochemicals for human health. This indeterminate annual produces yellow or gold, cherry-sized fruit, contained in an open calyx or papery husk. Our research at University of Maryland has been focused on high-tunnel trials to extend the market window for *P. grisea* fruit sales, and N-rate studies to determine fertilization requirements. Seed can be purchased from several vendors, but be careful to order the correct species. There is some confusion as to the different cultivated species for ground cherry and goldenberry (P. peruviana). The latter is a taller, upright plant with larger fruit. Seeds for commercial production should be germinated indoors and transplanted when they would no longer be exposed to freezing temperatures. Prepare your soil with appropriate amendments as noted on a soil test before planting. Plants should receive no less than 100 lb N per acre, in-row. Potassium requirements seem to be high for this crop so potassium should be on the high-side of optimal. Irrigation and soluble fertilizer injection is preferred for supplemental nitrogen and potassium. The transplants may need to be staked for initial support. The P. grisea plants may begin to flower before you transplant. The plants will eventually begin to grow in a prostrate, sprawling manner. Some attempts at pruning lower branches or trellising them may be helpful for controlling growth to aid in harvesting. The P grisea plants can mature in 65 days after germination, but full production needs at least 80 days. When ripe, the husk will turn a tan color and will have a papery texture. The fruit will be completely orange in color and will fall off the plant. A fruit catchment system can be devised or laying ground fabric before planting will help keep the fruit husks clean. The flavor has been described as uniquely sweet, with a custard-like pineapple taste. Harvest yield has been between 20 and 40 oz of fruit per plant over the growing season. The most important pest observed was Three-Lined Lema beetle (Lema trivittata), a member of the potato beetle family. This pest is a problem when plants are establishing in the spring, but are less of an issue in summer due to the plant's growth rate. White fly can become a problem as plants became more stressed in late summer under plastic. Fusarium crown rot was observed in high-tunnels in late June and continued into late summer, reducing number of plants. Potassium deficiency was observed in late June and continued through summer until study was terminated in early August. In summary, high tunnel production increased the market window 2 weeks earlier than outdoor production. However, without adequate ventilation, plants failed by August due to summer heat stress, disease and pests. The market price (farm markets and grocery stores) of the fruit is between $1.00 and $1.33 per oz, which makes it a valuable alternative crop for the Mid-Atlantic region.

GROWING HOPS AS A FARM ALTERNATIVE

Bryan R. Butler Sr.
University of Maryland Extension

With recent changes to the Maryland Alcoholic Beverage Laws and the dramatic increase in the number of breweries in Maryland farmers and other entrepreneurs have had an increasing interest in growing ingredients locally to produce beer. The base of information for growing hops in this climate is very limited and information on best management practices, post harvest handling, and economics are needed.

The program at WMREC developed from information gathered from key informants about the need to provide Maryland-based research on 24 varieties and cultural practices for the production of hops and barley, as well as postharvest management and economic evaluation.

This work is greatly facilitated by the Partnership developed with the largest brewery in the state, Flying Dog Brewery.

In the first four seasons, growers have received information in the form of a growers guide and a UME factsheet, been exposed to IPM recommendations, fertility information, and cultural practice recommendations. Also, evaluation of new varieties not grown in Maryland before and, new for 2019, an heirloom variety which has been in Maryland nearly 100 years that has been added to the evaluation process.

Overview, Hop Yard Establishment

Soil and Site Preparation: In Maryland's climate, it is critical to select the best site possible. This will help to reduce the negative effects of environmental stresses caused by extreme heat, high humidity, and erratic rainfall. The site should have well-drained soil, full sun, good air circulation and accessibility, and be clear of frost pockets. Soil should be tested at least one year in advance of planting to ensure time to develop a nutrient management plan and allow time to make the proper fertility and pH adjustments. Pay particular attention to pH, phosphorus, and potassium. Be aware of the previous crops, potential herbicide carryover, and the existing weed population. Perennial weeds need to be controlled prior to planting to help reduce weed pressure. Sod establishment in the fall prior to the year of planting will help facilitate future hop yard growth, prevent soil erosion and nutrient runoff, and suppress weeds. Tall fescue should be planted between rows in spring or fall prior to a hop yard establishment. Availability of water is needed for drip irrigation.

Variety Selection: The primary goal of the partnership between Flying Dog and the University of Maryland is to identify varieties acceptable for Maryland's climate. We are screening 24 varieties in an effort to identify those that might be better suited to be grown in Maryland, while still possessing the characteristics desired for brewers to make high quality beer. Varietal information, such as yield and brewing quality, are discussed later in this publication.

Planting: April through early May from transplants.

Fertility: All nutrients and soil pH, except for nitrogen, should be addressed based on soil test results prior to planting. Nitrogen should be applied the first week after planting, three weeks later and then three weeks after that, at a total of 75 pounds of nitrogen per acre for the first year hop yard.

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He is a 1984 Graduate of the University of Maryland College of Agriculture and Life Science in General Agriculture. He also holds a Master's of Science in Environmental Biology from Hood College.

He provides research-based information to commercial producers and is involved in a number of research projects including, Brown Marmorated Stink Bug in tree and small fruit, Spotted Winged Drosophila in small fruit, pumpkin variety trials, small fruit and vegetable production, the use of high tunnels, as well as mobile tunnels. Over the last ten years he has coordinated apple rootstock trials and demonstrations of various rootstocks at two spacings trained to tall spindle on a four wire trellis system. He has been involved with providing research based information to the Maryland Craft Beer Industry for the last six years with hops, barley and rye trials located at the Western Maryland Research and Education Center in Keedysville, Md.

Weed control: Apply glyphosate pre-plant to rows to burn down all weeds prior to planting. Use burn down product as needed to control weeds in the row throughout the first season. Avoid burning hops with drift from burndown products.

Irrigation: Regular and consistent watering is essential. Plants can grow ten inches per day and need water but should not have "wet feet." Maintain adequate moisture in the soil profile but do not allow water to puddle on the soil surface or for the soil in the hop yard to have a "muddy" texture. Irrigation should be run as often as four days per week during hot and dry periods.

Trellis: Trellises need to be well anchored and able to support a cable 18-feet high to allow the hops to reach their full potential. Posts should be 4 feet in the ground with plants spaced 3½ feet within a row and 12 feet between rows. Row spacing in Maryland needs to be wider than in commercial hops production of the Pacific Northwest due to our much more humid climate. Wider rows facilitate air movement and help reduce disease. It is important that your row spacing is suited to your equipment and that, when the plants are fully mature, operations in the hop yard can continue without damaging the plants.

Training/Pruning: Use one string per plant and encourage all the growth of the plant to climb the string. This will help the plant establish a strong root system and may help to produce a light crop the first season.

Pest Control: Weekly integrated pest management (IPM) scouting is a must for successful hops production in Maryland. Rapid deployment of control measures can make all the difference between success and failure of a new planting. Growers should be proactive rather than reactive. This consists of walking the rows observing overall condition of your plants, looking at vigor, color of foliage, discoloration or browning of leaves and presence of insects or mites. It is important to examine both the upper and lower surfaces of the leaves with a magnifying glass or hand lens to see mites or early infestations of leafhoppers.

Major arthropod pests include potato leafhoppers and spider mite outbreaks. These pests can show up early in the growing season. Japanese beetles may be a pest later in the season and can be difficult to manage with labeled products.

The major weeds of concern in the UMD hop yard are bindweed (*Convolvulus arvensis*) and horsenettle (*Solanum carolinense*); both of which are herbaceous perennials, and as a result, are difficult to control in a perennial crop such as hops. During late winter/early spring dormancy, products such as Scythe and Pendimethalin can be used. In-season weed control (hops greater than 6 feet) can be achieved with applications of Goal, Scythe, Aim, and Chateau. Label restrictions and pre-harvest intervals are major hindrances with weed control in a hop yard.

Hops downy mildew (*Pseudoperonospora humuli)* is by far the most prevalent and significant disease of Maryland hops. This disease thrives in Maryland because of our hot, humid summers. The pathogen overwinters inside dormant buds and will reappear every year when conditions are conducive for disease development. Preventative, scheduled sprays are critical to keep this disease at bay.

Management of an Established Hop Yard

Optimal Fertility: A total of 200 pounds of nitrogen per acre, per year, should be split-applied into four applications starting the first week of April, followed by the fourth week of April, third week of May, and second week of June.

Weed control: Apply Solicam DF + Scythe to burn down winter annuals and provide spring pre-emergent weed control.

Irrigation: Regular and consistent watering is essential and follows the same guidelines as establishing a new hop yard outlined above.

Spring Pruning: This can be done mechanically or with a desiccant in early May (May 7th). Either way, the critical objective is to completely remove all green tissue above the soil to encourage the plant to push up new strong bines from the crown.

Training/Pruning: Two strings per plant, selecting two or three healthy, strong, undamaged bines per string.

Pest Control: Weekly IPM scouting is a must for successful hop production in Maryland. The same pest control measures taken to establish a hop yard outlined above are crucial to maintain a successful crop year-to-year.

Harvest

This project is not just about growing excellent hops in sufficient quantities, they must be useful to craft brewers in Maryland, so it is also about demonstrating scalable technologies to provide a high-quality product in a useable form to brewers. This meant harvest and post-harvest handling had to be an integral component of this experiment.

Timely harvest is critical and needs to be performed consistently and within a narrow window of time to ensure maximum quality and comparison of varieties. To facilitate this, Flying Dog's investment in the partnership included joint funding of a mobile harvester. The harvester ensured that each variety was harvested in a timely and consistent fashion, and ensured the data collected on each variety regarding yield was (and will continue to be) consistent.

The cones were harvested at 25 ± 4% dry matter, and in 2018, all 24 varieties were harvested within a 12-day period. Harvest of the 24 varieties stretched from August 12 through August 24.

Harvest dates have varied from July 29 to September 8. Most days we have to wait for the plants and ground to dry, so harvest wouldn't start until early afternoon. Then, it was essential to get the cones into the dryer quickly because the moisture and humidity during the season was so high. This year, we used a dehumidifier inside of the dryer to get the moisture out of the hops as fast as possible (reducing moisture content from about 80% down to 8% in less than 24 hours).

Processing

The hops are processed on-site at the research facility after harvest. The hop cones were placed in the oast immediately following harvest and dried within 24 hours to 8% moisture. They were frozen in sealed bags using the liquid nitrogen system until they could be ground up in the hammer mill and then run directly into the pelletizer. The pellets were not heated above 110°F during pelletization, which required close attention. Once pelletized, they were placed in vacuum-sealed bags and frozen.

Most of the same processing techniques were used in 2018 to maintain best practices for processing hops and to minimize the number of variables in this project. Because the hops needed to be harvested in a shorter timeframe in 2018, they were vacuum-packed and stored in a freezer once they were dried. This kept them stable in between processing runs while we finished the harvest. Processing the hops cold also improved efficiency, an unexpected discovery out of necessity.

The top rated hops after 6 years were:

- Vojvodina: Floral and melon aromas in 2018 and 2017, with the addition of a tropical and citrus pop in 2018.
- Southern Cross: In 2016, this hop exhibited a fruit punch profile, but 2019 brought more distinct citrus notes. Maintained good quality but yields decreased. Yet difficult to maintain a productive stand.
- Southern Brewer: This variety traditionally used for bittering, not flavor or aroma; however, this variety grown in the UMD trial possess brew qualities that align with the most popular hops coming out of the Pacific Northwest. Citrus, melon and resin dominate its profile.
- Glacier: Huge fruit and pine with subtle herbal and floral notes as it matured, compared to much more prominent resinous notes the year prior.
- Sorachi Ace: Lemon, citrus and spice profile mimics what is expected from this variety grown in other areas of the United States.
- Amallia: No yield in 2017, but the 2018 harvest brought a unique combination of tropical fruit and earthiness.
- Canadian Red Vine: While this hop had the best yield in all years, the profile is a less-desirable combination of onion, garlic and herb. May be better suited as a backdrop.

BLOOMS, BUGS & BIRDS: AN ECOSYSTEM ENCOURAGING PREDATORS AND PARASITOIDS IN OUTDOOR PRODUCTION BY COMBINING IPM, INSECTARY PLANTS, AND NESTING BOXES

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Creating an ecosystem that attracts and supports naturally occurring predators and parasitoids can help bolster a free and silent insect and animal army that will aid in managing plant pests and help reduce the need for some insecticide applications. By combining Integrated Pest Management (IPM) practices with carefully chosen insectary plants, and Bluebird nesting boxes in your outdoor growing system, you can create a more balanced food web. Leveraging the natural interactions between plants, insects, and animals can help increase natural controls and save time, money, and exposure during the outdoor growing season.

An Integrated Pest Management Scout provides a dedicated set of trained eyes that will frequently monitor your crop and provide:

- Proper identification of pests (insect, disease, and abiotic factors)
- The pest's life cycle
- An understanding of how the pest interacts with your crop
- Their function in the food web
- A variety of control options (cultural, mechanical, biological and/or reduced-risk chemical) to manage pest populations below economic or aesthetically damaging levels.
- Data collected through the scout's diligent record-keeping will allow your plant pest control efforts to be proactive vs. reactive.

Additionally, an IPM Scout will monitor your crop after control measures have been implemented and evaluate their efficacy. This will allow you to make proper control strategy choices which are accurately timed to the pest's most vulnerable life stage, thus improving effectiveness while saving you money.

Combining IPM management strategies with the design and implementation of insectary gardens or planted pots within your crop will add a secondary food source (pollen/nectar) for naturally occurring pollinators, predators, and parasitoids. Our goal is to create a complex, multi-functioning system that supports a variety of insects.

When creating an insectary planting, choose a variety of plants with different architecture, as well as different flower structures. We want to provide plants that are blooming for as much of the growing season as possible. We are living

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Heather is a popular regional speaker who has lectured at numerous professional organizations, businesses, and special interest groups. She entertains and educates audiences with original photos, videos and stories based on personal experience, formal education, and specialized training.

She is also the President of The Maryland Bluebird Society, and Ladies in the Landscape, which supports women working in horticulture and related professions.

in a warming world with an extended growing season. Therefore, choose a variety of plants so that the overall design will provide blooms that start in the early spring through the late fall, and every interval in-between.

The results of many pollinator and beneficial insect trials provide a variety of plant choices for our geographic region that perform very well in attracting and supporting important beneficial insects such as parasitic wasps, predatory bug, and more that target aphids, lace bugs, scale insects, whiteflies, caterpillars and other plant pests in outdoor production and the landscape.

The addition of Bluebird nesting boxes gives your insect plant pests a

1-2-3 punch! Birds are great insect predators. They can eat 400-500 million tons of insects each year. A nesting trail provides safe homes for the Eastern Bluebird, as well as other native secondary cavity-nesting birds. These birds have struggled with a loss of habitat and reduced populations due to urban sprawl and fragmentation. They have also been outcompeted by non-native, invasive European Starlings and House Sparrows for food and nesting sites.

Birds are sensitive eco-indicators. By monitoring and recording the success of the broods along the trail, you provide a valuable ecoservice to native birds. The data collected throughout each nesting season is collected and shared with the North American Bluebird Association and the Cornell Lab of Ornithology, documenting the success of the program and the overall quality of the local environment.

By combining IPM Management practices, insectary gardens, and nesting boxes, we strive to create a multi-functional, diverse landscape that supports a complex habitat which sustains numerous insect and animal populations and a more balanced ecosystem. Attracting and supporting beneficial insects in and around your crop can aid in controlling insect plant pests and help reduce the need for some insecticide applications.

HYDROPONIC SYSTEMS FOR BEGINNING FARMERS

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What is Hydroponic Production?

Hydroponic production techniques can be a viable alternative to soil-based vegetable culture in greenhouses and/or other protected culture systems. In traditional greenhouse/high tunnel production systems, when growers are forced to utilize mineral soils repeatedly there is a greater likelihood that soluble salt levels will increase dramatically over time to the point that a reduction in crop yield and produce quality may be observed. Mineral soils cropped continuously in greenhouses/high tunnels may also observe increased populations of both plant parasitic nematodes and soil borne pathogens that can equally compromise crop yield.

Hydroponic production systems can be quite variable in their set-up and design, but they all require that a nutrient enriched solution bathe the roots continuously to ensure plant hydration and nutrient access. Some hydroponic systems require that inert substrates like perlite, vermiculite, coir, or rockwool be used in containers, bags, or troughs to support the crop being grown. In NFT (Nutrient Film Technique) systems crops are grown in poly gutters with a nutrient enriched solution running through the troughs continuously over the roots. In Deep Water Culture (DWC), large reservoirs of nutrient enriched solution are covered with Styrofoam rafts. Holes are cut into the rafts from which a small net pot containing the crop to be grown (usually lettuce) is placed. The net pot containing the plant is suspended in the hole and the roots of the plant are threaded through the hole cut into the raft and are immersed into the reservoir of nutrient solution.

The Market for Hydroponic Produce

The success and/or failure of hydroponic operations can be linked to the ability of the grower/operator to market their crop effectively. The produce industry is extremely competitive and hydroponic vegetable prices have been level or slightly declining across the U.S. due to increased competition from both Mexican and Canadian based operations. Hydroponic produce is often viewed as 'superior" to vegetables that are produced in open fields by many consumers because of the "perception" that produce grown in protected culture systems is "more" bacteriologically safe than produce that is field grown. Every outbreak of food borne illness linked to field produced greens drives customers to source more regionally produced hydroponic greens.

Large hydroponic operations (10 acres or more) often have lower per unit input costs than smaller operations (due to the economies of scale) and can often offer hydroponically grown produce at a lower price point than some of the smaller family-run produce operations that can be found in the Mid-Atlantic region. Small scale hydroponic operators however can often be more flexible in their production plans than large operations and can tweak their product mix more readily to meet emerging consumer needs and wants.

Water Quality, A Key Issue for Hydroponic Operators

Beginning farmers and farmers looking to diversify into hydroponic production should evaluate the quality of the water that they are planning to use in their operation first before making a new investment into greenhouse structures or additional production infrastructure. In PA, growers have detected an array of water quality issues that have forced them to drill new wells, connect to public water systems, and/or install expensive water treatment equipment to grow high value horticultural crops in greenhouse and hydroponic production systems.

Sodium and chloride are the two most serious water contaminants that have thwarted the expansion and/or investment plans of growers/farmers looking to operate hydroponic operations in PA. Contamination of aquifers from road salt or saltwater intrusion (from historic natural gas and oil exploration) has contributed to many growers' production woes. Reverse osmosis is often used to combat elevated sodium chloride content in well water supplies. Reverse osmosis systems can be expensive to install and their price tag ($12,000 to treat 5000 gallons a water day) can be cost prohibitive and possibly grossly inadequate from a volume perspective to meet crop needs. If possible, consider evaluating the quality of all farm water sources before signing a real estate purchase agreement. Once the property is under contract you may have no recourse but to consider an alternative water source or the installation of a water treatment system if you are going to pursue high value horticultural crop production.

Hydroponic Crops for the Mid-Atlantic Region

Crops grown in hydroponic culture include lettuce, arugula, watercress, rock cress, cucumbers, tomatoes, peppers, eggplant, cut flowers, tulips, basil, strawberries, etc. Every hydroponic crop has unique pH and fertility requirements so growers must be prepared to develop a customized fertility program for each crop to be grown. Daily monitoring of nutrient solutions coupled with regular sap and/or tissue testing should be carried out by growers to maintain fertility and the target solution pH.

Tomatoes, lettuce, cucumbers, and peppers are the four major crops being raised by most hydroponic growers. Small scale producers often grow tomatoes, peppers, and cucumbers in “bag” culture. In bag culture systems seven-gallon polyethylene bags are filled with perlite, coir-based potting media, or peat-based potting media. One to two plants are transplanted in each bag and are spaced in a single or double row on the greenhouse floor. One to two drip emitters are placed in each bag and the crops are fertigated on a regular schedule. Most hydroponic growers using bag culture systems have a two-fertilizer injector set-up and pull prescriptive amounts of nutrients from each stock tank to deliver a nutritionally complete solution to the crops being grown.

Lettuce, greens, and some herbs are generally produced using NFT systems using a network of troughs or through Deep-Water Culture Systems (DWC) which use crop containing Styrofoam rafts floating on a reservoir of nutrient solution. NFT and DWC systems often require a larger capital investment than bag culture systems for new and beginning growers. Since there is no media to act as a buffer in NFT or DWC systems any drop or rise in nutrient solution pH or EC (Electrical Conductivity) can prove to be disastrous for the grower unless the issue can be resolved quickly. In bag culture systems media acts as a buffer so pH and EC swings should be less dramatic with less potential crop loss when something goes awry.

For additional information on hydroponic production systems please contact the author at tgf2@psu.edu .

ADVOCATING FOR YOUR FARM ONLINE

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It is important as farmers to make a connection with our consumers. Social media allows us to reach consumers both near and far. Telling our authentic, personal stories of food and farming is what consumers crave. The average consumer is at least one if not many more generations removed from the farm and has become skeptical of what they think farmers are doing to raise and grow their food. Additionally, the science of modern agriculture can seem foreign to consumers. As farmers, we need to get out in front of our story and advocate for our operations online. It is hard to open your farm up, even online, because most farmers are introverts and fiercely private, after all our farms are not only our livelihoods, but also our homes, where we raise our kids and where we leave our legacy. But if we don't tell our stories, our stories will be told for us… and it's likely to be inaccurate and entirely off base. Advocacy requires work but it also facilitates change. Learn how social media can be used for positive communications about food and farming.

Jennie Schmidt is part of Schmidt Farms Inc in Sudlersville, Maryland. Together with her brother-in-law, she manages a third generation family farm growing grains, vegetables, and wine grapes on the Eastern Shore of Maryland. When she's not on a tractor, Jennie is a state and national agriculture leader having served as the first female board member and first female president of the Maryland Grain Producers Utilization Board, and currently serves as the Maryland delegate to the U.S. Grains Council. She is a national and international speaker telling the story food and farming. She is passionate about connecting people with food and farming, emphasizing the importance of global food access and the importance of sustainability in our food supply. Jennie, whose first career was as a Registered Dietitian, holds a BS in Human Nutrition and International Agriculture from UMASS and an MS degree from the University of Delaware in Human Nutrition with a focus on Food and Agricultural Biotechnology.

PASS AND OTHER GOVERNMENT PROGRAMS SUPPORTING FARM TO FOOD BANKS

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Pennsylvania Agricultural Surplus System (PASS)

Feeding Pennsylvania is the state association of Feeding America food banks. Feeding PA promotes and aids our member food banks in securing food and other resources to reduce hunger and food insecurity in their communities across Pennsylvania. Feeding PA is the statewide contractor for the Pennsylvania Agricultural Surplus System (PASS) program through the Pennsylvania Department of Agriculture. There are 13 partner food banks covering all 67 counties in Pennsylvania to help administer PASS and distribute local products to neighbors in need.

PASS funds are used to procure Pennsylvania grown, raised, and processed food products. The program seeks to reduce waste by providing a market for product that would otherwise be left in the field. The PASS program is typically seen as one of the food banks' programs most focused on fresh, healthy foods – produce, meat, eggs, dairy products, etc. Since the PASS program first received funding in 2015, approximately 65% of funds were used for local fruits, vegetables, and potatoes. There have been over 150 vendors in the PASS program from 50 Pennsylvania counties. Food banks look to work together with vendors on a fair price – allowing growers to cover the costs, while allowing food banks to increase their impact and the number of households served.

All types and varieties of produce are accepted and distributed through the PASS program. Food banks will work with growers on "seconds" or #2's to help provide a market for those products that may be more difficult to sell in traditional channels. Food banks can work with growers to accept surplus product during harvest, but also are willing to partner with growers on strategies for production of specific varieties and quantities as planning gets underway for the upcoming season.

USDA Farm to Food Bank program

The Farm to Food Bank program (F2FB) allocates additional dollars to states to build relationships between agricultural producers and the charitable food system through donated products. F2FB funds are available to cover the harvesting, processing, packaging, and transportation expenses related to product donated to PA food banks. PASS dollars are used as the matching funds for the F2FB grant. If your organization donates product or is a non-profit growing produce exclusively for donation, F2FB can help cover most costs incurred with your donated products.

USDA Local Food Purchase Assistance program

The Local Food Purchase Assistance program (LFPA) is a new program starting in the Spring of 2022. The LFPA seeks to maintain and improve food supply chain resiliency and will distribute local, nutritious foods and beverages to serve feeding programs and meet the needs of local communities.

Tom Mainzer serves as Director of Agricultural Partnerships for Feeding Pennsylvania. He works with agricultural producers and food manufacturers on opportunities to support Pennsylvania's charitable food system, all while helping to reduce hunger within the Commonwealth. Prior to joining Feeding PA, Tom worked with the Pennsylvania Department of Agriculture as their Agricultural Trade Specialist assisting the Commonwealth's food and agricultural producers and processors pursue export sales and other international business opportunities. Tom resides in State College, PA with his wife Emily and daughter Kathryn. He is a graduate of King's College and received his MBA from Lehigh University.

WHAT IS THE RETURN ON YOUR MARKETING DOLLAR?

HOW ARE FARMERS COPING WITH SUPPLY CHAIN DISRUPTIONS?

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Introduction

A supply chain encompasses a network of organizations and activities that produce and move a product to the end users. A supply chain can be greatly delayed by an unexpected change to any process in the chain, thus slowing down the delivery time of products to the final consumer. A Supply Chain Disruption is a sudden interruption or crisis that negatively impacts the flow and delivery of goods to customers. This can happen suddenly and unexpectedly because of a natural disaster or global events like the Covid-19 pandemic.

In 2020, many regions in the United States were placed in lockdown to control the spread of the pandemic. In New Jersey, non-essential businesses were shut down by emergency orders for several months. This caused delays in transportation as many regions and countries restricted movement of land, sea, and air carriers for delivering goods. The delays lead to a ripple effect because of shortages of supply, then reducing productivity within businesses. A study by the Institute for Supply Management (Industry Week Staff, 2020) found that 75% of businesses have experienced supply chain disruption due to the pandemic. Farmers in New Jersey have had to deal with slow shipping from overseas, increased material costs, labor shortages, increased labor costs, scarce young plant genetics, etc.

Lockdowns and social distances caused more people to eat at home and work at home and increased shopping in grocery stores, home improvement stores, garden centers, farm markets, etc., which were all considered essential services. This caused logistical bottlenecks as orders from restaurants and other purchasers were canceled, while online, grocery store, and other sales increased. Farm markets were deemed essential services and saw increases in their customer base and sales by turning to online sales and contactless pickup. Since January 2020, consumer demand for grocery products in New Jersey increased by 23%.

Employment rates among low-income workers (<$27K) dropped by 32% (https://tracktherecovery.org/). Tropical Storm Isaias (2020) and Hurricane Ida (2021) brought flooding and tornadoes to New Jersey, leading to United States Federal Emergency Management Agency (FEMA) major disaster declarations. Farmers faced supply chain challenges and thus shortages in essential input. Labor is often their biggest costs, and they are managing rising labor shortages and labor costs. Recovery from the disruption is estimated to take 1-4 years depending on how demand from changes in demand continue to change.

To manage supply chain disruptions:

- Develop a Supply Emergency/Backup Plan
    - o Outline different ways of supply delivery.
    - o Develop an emergency budget.
    - o List other suppliers when traditional sources fail.
    - o List other sources of capital to deal with shortages.

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- Have a safety stock
    - o Have inventory of non-perishable supplies.
- Conduct a Supply Chain Vulnerability Audit
    - o Conduct a risk analysis to identify the weakest link in the supply chain.
    - o Then identify alternative supplies or processes.
    - o Consider social and environmental factors that can impact the transportation routes and identify alternative strategies.
    - o Look for decline in quality or late delivery.
    - o Consider suppliers financial health and be prepared to support them—if they go out of business, you could go out of business.
- Identify Alternative Suppliers
- Make a list of suppliers you can partner with in case your current supplier can fill your order.
- Consider suppliers from different geographical regions and develop a relationship with them.
- Manage Product Demand
    - o If you have multiple products and one is not supply constrained, offer temporary discounts or other purchase incentives on the one with no supply constraints.
    - o Temporary Rationing- Limit how much of the constrained product each customer can purchase.
- Consider Implementing New Software
    - o Inventory management
    - o Online sales

In New Jersey, because we are the most densely populated state in the United States and are located in the highest income consumer market, many farmers have small land holdings and market their products directly to consumers. Most of them were able to successfully move to online sales during the pandemic when there was a surge in the use of online platforms. Online platforms make it easy for customers to purchase from local producers. They give producers tools to manage inventory, customer communications, sales, and delivery options. Online platforms can set up accounts for markets and cooperatives but are primarily designed for individual producers. Some online platforms do not require customers to create an account; two-thirds of customers will leave a site if required to do so. It takes a lot of time to set up and manage these sites, and they can be expensive, thus you need to be prepared to spend the time to make it work.

The ten most common online platforms are:

1. Local Orbit: https://localorbit.com/
2. Farmers Web: https://www.farmersvveb.com/
3. What's Good: https://soLircewhatsgood.com/
4. Local Food Marketplace: http://home.localfoodn1arketplace.com/
5. Grazecart: https://grazecart.com/
6. Red Foods: https://redmarketmn.com/
7. Locally Grown.net: http://locallygrown.net/welcome
8. Farm Spread: https://twww.farmspread.com
9. Barn 2 Door : https://wvvw.barn2door.com/
10. Farm Match: https://www.farmmatch.com/sellonline

The pandemic will have many possible permanent impacts. Consider:

- Online sales platforms provide a great opportunity to reach new customers.

- Buyers are looking for quality products without standing in the long queues and meeting the social distancing guidelines.
- A good brand gives peace of mind to consumers.
- Producers set up an online "store" with their products and prices listed. Consumers visit the website, select products, fill their "cart," check out, drive to the farm or pickup location; or, alternatively, have it delivered.
- Producers will have the option to offer the products individually or as a bag, bunch, head, box, or bundle.
- Buyers love local, but they love convenience more. Online platforms offer both.

Plan for recovery:

- One risk management strategy is to keep expertise in house.
- Allow for employees to work part-time work.
- Consider eliminating unprofitable products.

As the pandemic continues, and to prepare for other crisis, use the 5 C's of Managing a Crisis:

1. Prioritize People - Customers, Suppliers, Employees, Yourself
2. Secure Supplies – Communicate to make sure supplies arrive on time.
3. Minimize Spending – Reduce spending so you can sustain the disruption.
4. Update Strategies – Review Risk Management Strategies to build resilience.
5. Embrace Innovation – Adjust and make Lemonade out of Lemons.

In conclusion, some financial risk management strategies you can use to the manage disruptions are:

- Purchase insurance – crop, property, liability, health, and life.
- Contain costs.
- Right size operations.
- Focus on good marketing strategies including online marketing.
- Consider having non-farm income.
- Diversify.
- Do tax planning.
- Reach out to neighbors in a way that allows them to open up.

FOCUS ON SUSTAINABILITY FROM A RETAIL PERSPECTIVE

Jessica Printy Groves, The GIANT Company

"There is no Planet B," said philosopher John Locke and at The GIANT Company, that idea has been a strong drum beat to the practices embraced, the partnerships forged, and the purpose our team drives toward as we work to heal our planet. In this session, attendees will gain an understanding of why The GIANT Company is focused on this topic, what they are learning more about, and how they see retailers being the meeting point for change and innovation.

Jessica Groves, community impact manager for The GIANT Company will share how the retailer is answering the calls of customers for product traceability with a HarvestMark pilot in 2022. She will also provide insights into a new partnership with FlashFood and how the brand invested in the food waste and food discount partner to keep food out of landfills while providing customers fresh produce at a discount. Jessica will also discuss how the company is building a long-term runway for change in agriculture production through research and innovation with partners at Rodale Institute and Harrisburg University to allow for all food retailers to embrace and drive real change.

INDOOR FARMS – ONE SOLUTION FOR YEAR-ROUND SUSTAINABLE PRODUCE

Abby Prior
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A Close Look at the Environmental Footprint of Salad Production in the U.S.

How do Mid-Atlantic supermarkets source their leafy greens? In the U.S., virtually all production of leafy greens sold in supermarkets is centralized in Salinas, California and Yuma, Arizona, two regions that can maintain a consistent year-round climate for growing. Once the product is ready for harvesting, the industry relies on a long, complex and opaque supply chain to fill the nation's supermarkets with packaged salads.

This centralized system of production is contributing to some of society's greatest environmental problems. The large output of water required to grow and wash the lettuce is deeply straining California's water resources at a time of increased wildfires and major droughts. In addition, shipping leafy greens thousands of miles and into every corner of the nation increases the carbon footprint of the final product.

The climate crisis is forcing the country to rethink food systems, and in particular, the ways in technology can be used to reduce the environmental footprint of industrial fruit and vegetable production.

Year-Round Sustainable Salad Production for the Mid-Atlantic

In the Mid-Atlantic, BrightFarms is the leader of local indoor farming for salad greens, a rapidly growing segment of produce that seeks to transition the production of leafy greens into sustainable hydroponic farms. Rather than shipping leafy greens from large, centralized farms on the West Coast, BrightFarms' Mid-Atlantic operations are in close proximity to urban centers to supply retailers with local and sustainable produce at scale. These sustainable hydroponic farms use 80% less water, 90% less shipping fuel and 95% less land than field grown greens traveling from th west coast.

BrightFarms opened their first farm in 2013 in Pennsylvania, and began servicing retail chains throughout Greater Philadelphia. Today, BrightFarms operates two large-scale greenhouse farms in Culpeper, Virginia and Selinsgrove, Pennsylvania that supply leafy greens to over 1,000 supermarkets throughout the Mid-Atlantic. Early on in their development, BrightFarms forged a close relationship with Ahold Delhaize USA (Giant Foods and The Giant Company), one of the Mid-Atlantic's leading retailers.

With a high population density, colder climate and long distance from California, the Mid-Atlantic is an ideal location in the U.S. for indoor farming development. In the coming years, BrightFarms plans to greatly expand their presence throughout the region, adding additional facilities and expanding their growing capabilities into new products.

Abby Prior is the Chief Commercial Officer of BrightFarms with responsibility for sales and marketing at the indoor farming company. Abby joined BrightFarms and the produce industry in 2015 as VP of Business Development. Over the last 6 years, BrightFarms has established itself as a leading grower of local indoor salads with 6 commercial scale farms across the east and midwest. Abby is a Board Member and Marketing Council Chair for the International Fresh Produce Association and sits on the Philabundance Food Advisory Council.

PRODUCE AUCTION STRATEGY AND SUCCESS

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Produce auctions, like other market outlets, reward growers who understand and respond to buyers' needs for quality, product selection, communication, certifications, and a variety of other factors. The following tips provide guidance for growers looking to get started selling at produce auctions.

1. **Get an A in produce grading.** Top-quality ("number 1") produce can earn top prices, if it is properly sorted (free of "number 2" or "seconds" product). Grade your produce honestly and appropriately. This may require doing some homework. Go to the auction and see how the successful growers are packing their produce. What characteristics make a tomato or a cucumber a number 2? Talk to buyers at the auction. Tomatoes that are sorted and packed separately as number 1s and number 2s, will bring better prices than unsorted tomatoes, which will sell for a number 2 (lower) price. A grower's reputation rests on quality and consistency and follows them through their auction career. It pays to spend the time sorting and grading.
2. **Extend the season.** Although growers don't need to grow a variety of crops to be successful at the auction (many growers only grow one or two crops), it is important to maximize the length of your season to avoid flooding the auction with your complete harvest at the same time as other growers. If you plant all your sweet corn in early May and harvest it all during the one week in August when everyone has sweet corn, you will be disappointed in the price. Try staggering your plantings or use high tunnels to get a head start on the season. Season extension will also help you the weather the highs and lows of the weekly price variations.
3. **Quantity counts.** Although growers of all sizes can sell at auction, most produce auctions (17 in Pennsylvania) are wholesale auctions and expect wholesale lots. The size of the lot will vary depending on the crop. Cantaloupes should be sold by the bin with 120-140 cantaloupes per bin. Sweet corn is sold in bin lots of at least 30 dozen per bin. Okra and zucchini are sold in half-bushel boxes, and growers should expect to have at least two to four boxes of each (all of the same grade and size). Do your research at the auction. Ask buyers what size box they like to see each item packed in.
4. **Packaging matters.** It may be tempting to pack produce in assorted boxes you have lying around the farm. The Food Safety Modernization Act (FSMA – sometimes pronounced "fisma") requires that produce that is likely to be consumed raw (tomatoes, peaches, cucumbers, melons, etc.) is always packed in new cardboard boxes or plastic-lined used boxes. Produce not likely to be consumed raw (eggplants or sweet corn) may be packed in clean used boxes. Tomatoes should be packed in specific 10lb or 25lb boxes for tomatoes which can be bought at the auctions. Some crops are packed in 1/2 bushel boxes; others are packed in 1 1/9 bushel boxes. These industry standards are based on typical product weight, box strength, and quality protection. If in doubt, visit the

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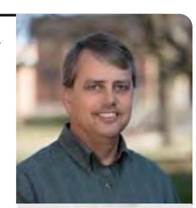

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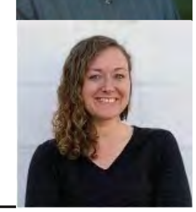

auction before delivering your first crop to learn how it should be packed.

t5. **(Food) safety first**. Food safety is important for all produce, regardless of where it is sold, and the auction is no different. Packaging should be clean inside and out. Produce boxes should never be set directly on the floor. Boxes or bins should not be stacked unless there are lids for the bottom boxes. Produce should be transported to the auction in clean vehicles (i.e. free of pet hair). At a minimum, folks handling produce should have clean hands, clean shoes, and clean clothes. To learn more about Food Safety, Food Safety Modernization Act and Good Agricultural Practices, go to https://extension.psu.edu/food-safety-and-quality/farm-food-safety.

t6. **Know your buyer.** Pay attention to who bought your produce. When you get a chance, ask the buyer what they liked about the produce and what they are looking for. Many buyers choose to source produce through produce auctions because it gives them an opportunity to socialize and connect directly with farmers. Knowing what your buyers are looking for will help you tailor your pack to your buyers and help you stand out from the crowd. Marketing slogans such as "Buy fresh, buy local" and "Know your farmer, know your food" have encouraged consumers, chefs, and wholesale buyers alike to understand where and who their food comes from. Farmers who take the time to build relationships with frequent auction buyers may be rewarded with loyalty, consistency, feedback about your products or new ideas, and higher prices.

t7. **Varieties are the spice of life.** Understand what varieties buyers are looking for. Varieties that you like for your family or even your roadside stand may not have the qualities the buyers want for their business. This is more important with some crops than others. For example, cantaloupe and sweet corn buyers have distinct variety preferences. Understand what types of sweet corn local auction buyers are looking for before you plant. Some auction buyers like white corn; others prefer bi-color. Some auctions do well with heirloom tomatoes (while others don't), and these types need to be packed in 10lb boxes rather than 25lb boxes.

t8. **Mind the GAP (certification)**. Third-party audits, like Good Agricultural Practices (GAP), are required for many large chain stores, wholesalers, and institutions. If you want these buyers to purchase your produce at auction, you may want to consider paying for a third-party food safety audit. The buyers that require these audits are often the bigger buyers. While they might not be able to pay the highest prices of the season, they do have the capacity to buy large amounts of produce, which may be a significant help when the market is saturated mid-season. If you grow in large volume, it would be worth your time to have it GAP certified. Make sure your GAP certified produce is labeled as such at the auction. (Check with the auction to see if they have a special label.)

t9. Y**our first day at the auction.** You may be tired of hearing it, but we'll say it again: visit the auction before you are ready to sell your goods. Learn what packaging is most appropriate for your products, and learn what qualities buyers are looking for in #1 and #2 products. Make note of labeling and product placement so that on your first day, you're prepared and ready to start selling. On the big day, arrive early – at least a half hour before the sale starts – and find a grower or manager to explain the process to you or Inquire at the auction office. In order to be eligible to sell, you will need to get a grower number from the office. After your product is properly placed and labeled, be sure to open a box or two so buyers can inspect the contents while they browse and bid.

These tips will get you started on the right foot, but the learning doesn't end here. Each season (and even each auction day) brings new opportunities to gather feedback on your strengths and areas for improvement. The greatest success is not necessarily achieved in one season; it is grown steadily through relationships and trust over time, perhaps years. We wish you a successful auction season!

To find a produce auction near you, consult the Pennsylvania Vegetable Marketing & Research Program auction directory: https://www.paveggies.org/directory/produce-auctions

To learn about buying at produce actions, view the following resources or contact the presenters.

8 Tips for Buying at the Produce Auction: https://extension.psu.edu/8-tips-for-buying-at-the-produce-auction

Produce Auction Virtual Tour and Info Session (webinar recording): https://extension.psu.edu/produce-auction-tour-and-information-session-for-buyers-webinar

RESILIENCE THROUGH DIVERSIFICATION: INTRO TO RESTAURANT SALES

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Background

We have heard the warning about putting all our eggs in one basket, and the COVID-19 pandemic especially drove this point home for those in food sales. Retail and wholesale businesses each experienced challenges and fluctuations that in one way or another impacted the growers that supplied them. Now many businesses struggle to respond to supply chain disruptions that limit availability of packaging materials and other inputs.

Turbulent times such as these remind us of the importance of market channel diversification. Think about it this way: if all your business in one market channel or from a handful of customers disappeared overnight, would you be in trouble? If so, it's time to diversify.

Farmers have many market channel options:

- Direct-to-consumer: CSA (subscription); farmers market; retail farm market/farm stand
- Wholesale: auctions; distributors; institutions (e.g. schools, hospitals); grocery stores; processors; restaurants

Restaurants can be a valuable market outlet for diversified fruit and vegetable producers. Though remember, in light of the disruptions to foodservice caused by the pandemic, it is not advisable to shift all of your business into this channel. Diversity is the key to resilience.

Restaurants: opportunities & drawbacks

Benefits include:

- There's high demand among consumers for a farm to table experience.
- Higher price points than some other market outlets
- Can drive new businesses (exposure and referrals)
- Grow interesting new varieties that are hard to sell through other channels
- Steady outlet with opportunity to plan in advance
- Access to feedback about quality and varieties that can benefit other sales channels

Challenges include:

- Crop planning is usually done on a handshake, and plans may change
- Coordinating schedules (many chefs are night owls, farmers are often early birds)
- Prone to last-minute orders and changes
- Seasonality may require some education
- Fulfillment or quality issues can have immediate damaging impacts
- Lower price points than direct-to-consumer

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Plan for success: logistics

A successful customer relationship is built on a foundation of careful planning. Consider the following logistics before launching a restaurant sales program.

1. Pack sizes & materials
    a. Search for information on standard industry pack sizes, and stock up on the appropriate materials – boxes, bands, paper, box liners, etc.
    b. You can make exceptions (half cases or by the pound) as needed
2. Availability ("fresh sheet")
    a. How will you share what you have to offer - spreadsheet emailed/faxed, online list, text message?
    b. Can you include photos and descriptions?
3. Order minimums
    a. What is the smallest order that makes it worth your while to make the delivery?
    b. Consider a delivery fee for orders under minimum
    c. Is pickup an option for small orders?
4. Payment
    a. What forms of payment can you take?
    b. When is it due – Net15? Net30? Cash on delivery only?
5. Ordering process
    a. How will you collect orders - by phone, online form/portal, email only…or any way that works for the customer?
    b. Deadlines - strict cutoff or on a rolling basis? How much time do you need to compile sales and harvest needs?
6. Deliveries
    a. Many restaurants have little storage; this might mean small deliveries more often. Can you deliver 2-3x/week? Which days?
    b. Will you need to hire someone to make deliveries, or do you have staff capacity?

Getting started

1. **Get a referral**. Ask friends and family if they know any chefs interested in working with a local grower.

2. **Go for the cold call.** After getting some experience reaching out to referrals, try hitting the pavement.

a. **Do your research.** Go in with an understanding of the types of foods on their menu, their existing farmer relationships (which might be listed on their menu or website), and what they're values are. Then refer to those in your conversation.

b. **Make it past the gatekeeper.** Whether you call, email, or show up, you're likely to encounter someone other than the person you need to speak with (usually the head chef or manager). It's their job to filter incoming requests and "bounce" anything that seems irrelevant. Be courteous and help them want to help you. Introduce yourself, explain that you're looking to connect with the person in charge of their ordering, and ask if they can help you get in touch. Timing is important: visiting on a major holiday (e.g. Valentine's Day) or in the couple hours before the restaurant's busy time (breakfast, lunch, or dinner rush, depending on the restaurant's specialty) is a good way to get bounced.

c. **Don't show up empty-handed.** Whether you're calling, emailing, or showing up in person, be prepared with something to give – a list of seasonal offerings, current availability list, samples, a farm brochure, or at very least a business card.

d. **Be ready to tell your story.** What are you offering, and why should they care? Write it down and rehearse it. Talk about your experience, passion, history – you are selling yourself as well as your products! (For more tips on telling your story, tune into Miranda Harple's presentation.)

Building a successful working relationship

Communication – Learn how (and when) each customer prefers to communicate and, if you are able to accommodate, you'll have the greatest chances of success. Some chefs prefer email; others like phone calls; and many are avid texters. Remember that chefs and farmers often have different work schedules.

Hype it up – Don't assume the customer already knows the difference between turnip or kale varieties or what's so great about a honeynut squash. A big part of sales is educating the customer. Photos can be really helpful, as are descriptions and suggested preparations. Share what you can to help the customer understand why those purple carrots are worthy of a place on their menu.

Managing expectations – Farming, weather, and bugs can be unpredictable and really throw a curve ball in our plans. It is likely that at some point during the season, you'll have to make some hard decisions: whether it's better to ship a lower-than-usual quality or "short" a customer, or which customer to short. Whenever possible, more communication is better than less. If you have to short a customer, let them know as soon as possible so they can try to make other arrangements.

Planning – Help your customers help you when you're loaded on a particular crop by giving them as much notice as possible. They may be willing to change next week's menu or hold off on ordering that item from someone else. Likewise, give a heads up on new and limited items. Sit down with the chef over the winter and look at the season ahead; make crop and menu planning a collaborative process.

Know your customer - The better you understand your customer, the better you can serve them and anticipate their needs. Keep up with their menus. Ask them what they like and what they don't like, and when they don't buy something you think they should, ask them why. Their answer might tell you something you didn't realize or expect.

Share the love – Restaurants love to tell their customers about the farms they source from. They may put farm names on their menu, on a chalk board in the restaurant, and post about you on their social media accounts. Share the love! Telling your network about the restaurants you serve is a way to express your appreciation and publicly reinforce your role as a food provider in the community.

NORTHEAST ERME GRANT: AGRITOURISM SAFETY AND LIABILITY: UPDATING BEST RISK MANAGEMENT PRACTICES FOR THE COVID-19 PANDEMIC

Claudia Schmidt, Penn State Extension; Chadley Hollas, Consultant; Lisa Chase and Kerry Daigle, University of Vermont; Michelle Infante-Casella, Rutgers University

A national survey in 2019 of producers with agritourism and on-farm direct sales found that liability and safety concerns were among the top challenges facing producers, with 81% of respondents concerned about liability issues, 73% concerned about managing visitor accessibility, 66% concerned about food safety, and 55% concerned about biosecurity. This was in 2019, before the COVID-19 pandemic. The pandemic has heightened concerns about safety and sanitation everywhere, and farms open to visitors are no exception. High-quality safety protocols, including handwashing stations and signage, are no longer optional; they are an essential measure for controlling the spread of COVID-19.

A multistate project team from Vermont, New Jersey, West Virginia, and Pennsylvania addressed these challenges with support from the Northeast Risk Management Education (NERME) Center.

Safety and Liability for Farms During COVID-19 – Project Website: https://bit.ly/3nOLH3s The project team has hosted eight online workshops and has followed up with farms to recruit and conduct safety assessments in Maine, Vermont, Pennsylvania, West Virginia, and New Hampshire.

The project team completed 57 on-farm assessments across Vermont and Maine, one virtual visit in Pennsylvania, and four on-farm assessments by local collaborators in West Virginia, for a total of 61 farm assessments. During the assessments, team members discussed challenges, barriers, and improvements needed regarding safety and liability for agritourism operations. Notes taken during the assessments were then transcribed and informed the creation of a unique farm plan that was then shared with each individual farm.

As a result of assessments, more than half of farms most frequently reported that they reviewed signage needs and posted signage to promote safety and/or signage related to liability as a result of discussions during assessments. About a quarter of farms implemented hand washing stations, updated information provided for guests prior to their visit, and reviewed assessment checklists for farm-safety. Farms also reported that doing assessments were helpful because they were able to view their farms through a fresh set of eyes and either see opportunities to improve safety and liability on their farms or reaffirm they were taking all the appropriate measures.

The most common issue seen across farms concerned the movement of visitors from one area of the farm to another. Some examples include:

- At an orchard and event venue, the parking lot was across a busy road from the main visitor entrance;
- At a farm with a corn maze and animal experiences visitors were required to park in an area next to a farm road frequented by heavy equipment and walk along it to enter the activity area;
- In order to reach the PYO spaces of one farm, visitors had the option to walk along the same pathway as the hayride, which was also taking visitors to PYO.

These concerns were managed by either more communication of the risks to visitors or by changing the flow of visitors around the farms. Farms of all types had similar issues. However, farms with similar activities tended to have more of the same types of concerns. Farms that offered experiences with animals needed to have a particular focus on biosecurity, both between people and between different animals and their paddocks/pens. Farms offering PYO experiences often welcomed more visitors at once, which led to concerns of how to manage visitor inflows and how to manage visitors successfully once they arrived.

In our experiences, farms with the least number of issues or concerns were those offering one experience, particularly education and direct sales. The more experiences a farm offered, the more risks tended to appear. The most helpful resources for managing these concerns were those provided by the University of Vermont Extension and by Rutgers University Extension. The workshops with safety-area specialists were also extremely helpful as well as the professional experiences of the consultant conducting the assessments.

Safety Resources (Rutgers):
Improving Handwashing Stations: https://bit.ly/2ZiCcA3

Considerations for Agritourism Operations During the Covid19 Pandemic: https://bit.ly/3lTOSWk

Agritourism Animal Safety Assessment Checklist https://bit.ly/3m3FOy1

Agritourism Emergency Response & Liability Assessment Checklist https://bit.ly/3m1Eiwr

Agritourism Employee Assessment Checklist https://bit.ly/3s3NzYS

Agritourism Operation Food Safety Checklist https://bit.ly/33lBZ0F

Agritourism General Farm Safety Assessment Checklist https://bit.ly/31XQasp

Agritourism Marketing Assessment Checklist https://bit.ly/3s3NLay

Agritourism Parking & Traffic Assessment Checklist https://bit.ly/3EUCLQ6

Additional Extension Resources:
Vermont Agritourism Collaborative: https://www.uvm.edu/extension/vtagritourism

Pennsylvania: https://aese.psu.edu/outreach/agritourism

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NORTHEAST EXTENSION RISK MANAGEMENT EDUCATION

USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

STOP THINGS FROM GOING WRONG: AVOIDING A CRISIS BEFORE IT HAPPENS

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Agritourism is an increasingly popular strategy for many small-scale farmers to raise farm income, diversify product lines, educate the non-farm public about farming, and enhance community engagement. Agritourism establishes farms as travel destinations for educational and recreational purposes. Agritourism encompasses a variety of on-farm activities, including direct marketing (e.g., farm market and pick-your-owns), educational activities (e.g., school tours and winery tours), entertainment (e.g., corn mazes and hayrides), outdoor recreation (e.g., hunting and fishing), and accommodations. The premise of agritourism is inviting the public to your farm operation. For many farmers, however, opening to the public is a new business model, necessitating a shift from a production-centric focus to one that includes service and hospitality. Importantly, agritourism also increases a farm's legal liability as farm visitors are exposed to risk factors that may result in injury or other harms. Dealing with a crisis is not limited solely to agritourism operations. A crisis can occur on any farm possibly due to a fire, accident, weather related event or possibly product safety concerns. Agricultural crisis management should emphasize the protection, recovery, and rehabilitation of agricultural livelihoods.

A risk management tool for many farm operations is the development and implementation of a farm safety plan to limit exposure to safety risks. A written farm safety plan outlines safety rules and procedures to maintain a safe environment for those living on the farm, employees, and farm visitors. Pre-crisis planning aims to identify risks and then find ways to mitigate or lessen those risks. It is important to note, however, that crisis management and risk management are two different things. Risk management means looking for ways to minimize risks. Crisis management involves figuring out the best way to respond when an incident does occur. As such, risk management is an important part of crisis management, but crisis management covers incident response, whereas risk management usually does not. Any event that has the potential to damage a farm's finances or reputation, may be cause for putting a crisis management plan into action.

A crisis can occur because of an unpredictable event or an unforeseeable consequence of a potential identified risk. Crises almost always require decisions be made quickly to limit damage to business. A crisis can come in many forms and may affect health or safety, farm finances, reputation, or some combination of these. Crises come in many forms, they can threaten a farm's operations, reputation, and finances. Some crises jeopardize lives, health, and safety. Other forms of crisis can involve food safety, data breach, and customer service incidents among others. There are several components to a crisis management plan. Many divide the plan into stages. In its simplest form the stages of a crisis include pre-crisis, crisis management and response followed by post-crisis. Presented will be strategies for developing a crisis management plan for farm operations. Know that the list of potential crises could get very long. But if you can prepare yourself in advance, you will be ahead of the game when the worst happens.

Bill Bamka serves as a Regional Field and Forage Crop Agent with Rutgers Cooperative Extension. Bill has been an Agricultural Agent located in Burlington County for 26 years. His major focus areas are in field crops, nutrient management, and alternative crops. Bill also has expertise in farm safety and risk management for agricultural operations and is an NFPA certified fire fighter. He has his B.S. degree in Agronomy from Delaware Valley College of Science and Agriculture and his M.S. degree in Agronomy from the Pennsylvania State University.

FROM FOOD SAFETY TO COVID SAFETY: RESPONDING TO RETAIL MARKETERS NEEDS

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Retail marketers of agricultural products were forced to pivot quickly early into the 2020 season. Online platforms, customer communication, and interpretation of CDC recommendations and state Executive Orders could feel like a minefield. The Rutgers Cooperative Extension On-Farm Food Safety Team, who provides educational outreach to produce growers on food safety topics, found itself providing COVID guidance. We learned early, just like farmers, that recommendations and guidelines change quickly impacting day-to-day farming and marketing norms.

While the 2021 season was more normal than the previous, we caution retail marketers to be prepared to pivot due to federal and local guidelines and customer comfort levels. 2021 season best practices suggested were:

1. Communicate your farm policies regarding COVID protections clearly online and on the farm through signage.
2. If you choose to no longer require masks indoors at the farm be understanding of customers who may choose to wear a mask. "Mask-free" environments are not enforceable, those who wish to wear masks must be allowed to do so.
3. When possible continue to provide order ahead and pick-up of items sold at your farm. This allows those who are unvaccinated or wary of those who are unmasked to still be able to shop at your farm.
4. Prepare your staff on how to handle disgruntled customers. Who is the right person at the farm to handle these situations? Have a plan on who and how you will respond.
5. Realize that you will not make everyone happy. The best you can do is to decide your farms policies are, stick to them, and communicate the heck out of them.

Informational resources were made available online for retail marketers to assist in their decision making. Live and recorded webinars for specific commodities and marketing venues, Facebook posts, and Rutgers Plant and Pest Advisory blogposts were used to inform agricultural producers about COVID restrictions and requirements. Topics included proper cleaning and disinfection for food contact surfaces on the farm and in the retail market, proper procedures for using disinfectant wipes on food contact surfaces, decision making tools for when workers became sick with COVID or had been exposed to COVID, and guidance on appropriate signage to notify customers of market policies. While the frequency of these updates has slowed, the information will remain available online should we find ourselves with more strict protocols on the federal and state level or if there is another pandemic in the future. COVID resources are available online at:

Rutgers On-Farm Food Safety COVID-19 website: https://onfarmfoodsafety.rutgers.edu/covid-19-information/

Rutgers Plant and Pest Advisory, Food Safety: https://plant-pest-advisory.rutgers.edu/category/food-safety/

Rutgers On-Farm Food Safety Facebook Page: https://www.facebook.com/RutgersOnFarmFoodSafety/

Meredith Melendez is an Agricultural Agent and Associate Professor with Rutgers Cooperative Extension and is based in Mercer County. Her areas of responsibility include produce safety, new and beginning farmers, and alternative agriculture. She is part of the NASDA On-Farm Readiness Review development team, a program developed to assess a farms readiness for a FSMA Produce Safety Rule inspection and is a Produce Safety Alliance Trainer of Trainers. Meredith has a B.S. in plant science from Ferrum College and a M.A. in environmental conservation education from New York University. She lives in Burlington County, NJ with her husband and two sons.

IMPACTS OF SUPPLY CHAINS AND REGULATIONS ON DIRECT MARKETING AGRICULTURAL OPERATIONS

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The COVID-19 pandemic presented both challenges and opportunities for agricultural producers, especially direct-marketers. One of the greatest challenges that producers faced was a supply shortage caused by many factors including global supply chain shortages, regional spikes in demand, and reduced availability of infrastructure due to staffing shortages and other labor policies. In addition to supply chain impacts, direct marketers were challenged by dramatic changes to federal, state and local regulations designed to mitigate the potential for disease transmission and to secure public health and welfare. This presentation will discuss how the COVID-19 pandemic impacted direct marketers and will discuss how producers were able to adapt their marketing strategies to provide consumers with a safe product while maintaining profitability.

The changing consumer during COVID-19

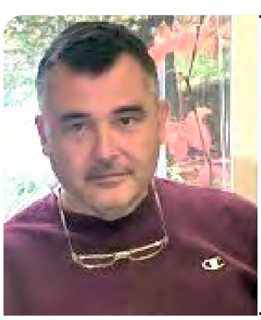
Several traditional marketing venues were strained in response to the pandemic. Perhaps the most impacted were on-farm, in-person sales and agritourism activities. These venues are typically among the most profitable activities for many producers. The pandemic also reenforced the value-added benefits of a safe, locally produced food system and as such created incredible demand for direct marketed agricultural products. Producers were forced to carefully navigate the increased demand for their products while ensuring the safety and welfare of the "new" local agricultural consumer.

Regulatory Compliance

During the COVID-19 pandemic, Extension educators, state and local regulators, and other service providers conducted several educational programs designed to share current, scientifically validated strategies to meet the demand for a safe food supply. Several factors including lock-downs, closures and other health and safety requirements were of particular concern since the regulatory landscape was constantly changing in response to federal and state guidelines. These educational programs were conducted using various media including virtual platforms and were designed to be both timely and accurate.

Global and Local Supply Chain Challenges

Several factors were responsible for supply chain challenges which impacted global, national and local supply chain supply. One specific example is the shortage of locally processed USDA inspected livestock products caused by the high demand for products, a shortage of labor and concerns and others. Global supply chain concerns resulted in shortages of products used to create value-added products such as glass jars and plastic packages.



Stephen Komar is an Agricultural Agent and Co Director of the Clearing Corporation Charitable Foundation Agribusiness Scholars Program. He has expertise in field crop production, direct marketing and agritourism and farm business management. Komar has degrees in soil science, crop physiology, and post-harvest ecology and has recently completed the mini MBA program at Rutgers University.

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