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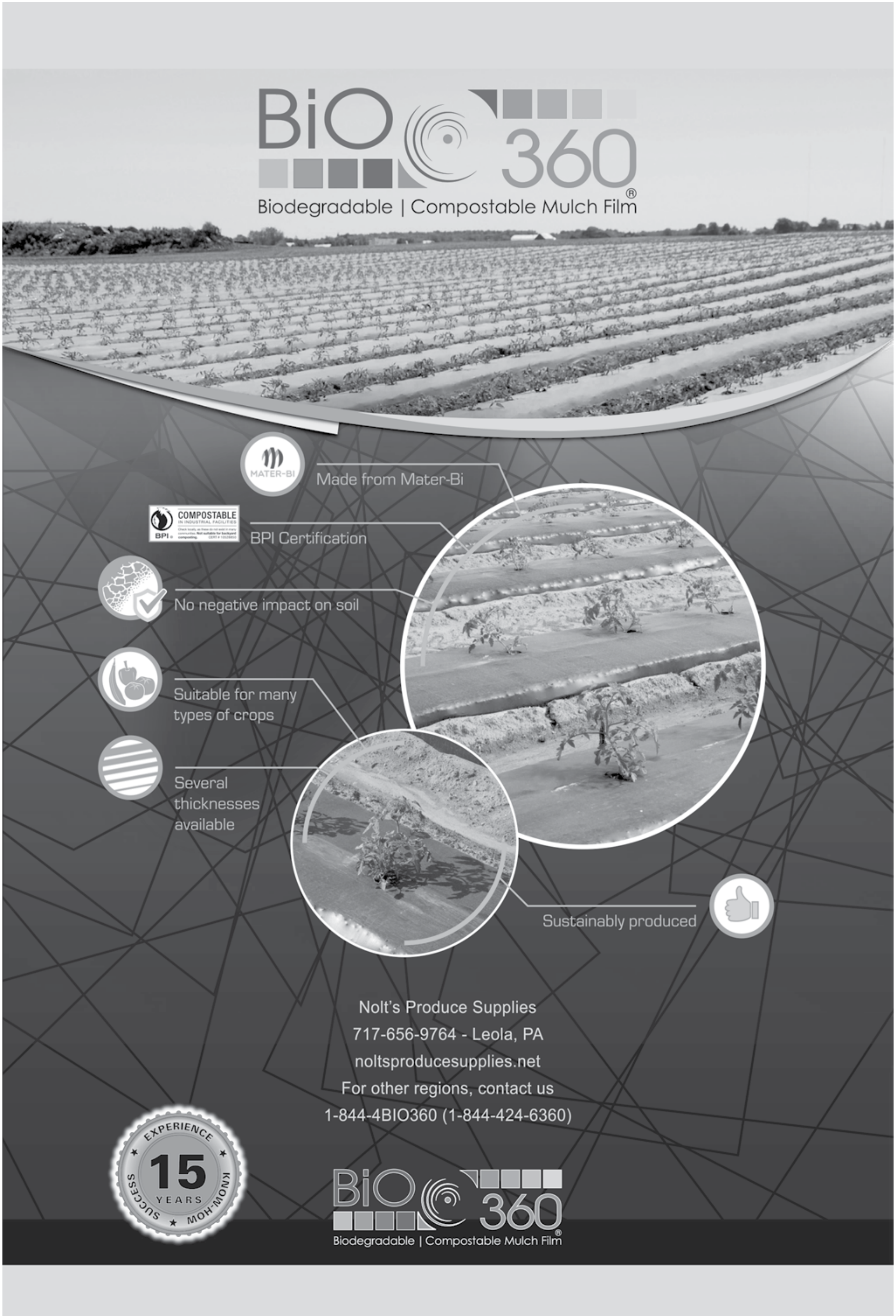
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WHAT ARE THE COMMON INSECT PESTS UNDER HIGH TUNNELS AND HOW DO WE MANAGE THEM?

Laura Ingwell and Samantha Willden[1]
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Producing specialty crops under high tunnels offers growers the benefits of crop protection and season extension in temperate climates. High tunnels can also reduce the incidence and severity of some diseases. However, many soft bodied insects and mites (e.g., aphids, thrips, whiteflies, and spider mites) as well as caterpillars and leaf-feeding beetles can reach higher densities under high tunnels compared to the open field. As high tunnel production gains popularity among growers in the U.S., more work is needed to identify pest challenges and options for pest management in this system. This is especially true for shoulder season and winter production, where less information is known of pest activity.

Common pests: Our previous work on high tunnel tomato, broccoli and cucumber concluded that high tunnels are likely to support higher pest densities compared to the open field (Ingwell et al. 2017). This was supported for aphids, whiteflies, hornworms, the crucifer caterpillar complex, and in some cases, cucumber beetles. In current research comparing pest presence on 16 farms across Indiana, aphids (species complex currently unknown) and fungus gnats were the most common pests on winter grown leafy greens (i.e., spinach, lettuce, kale, and Bok choy) under high tunnels. Managing aphids, and other common high tunnel pests present on winter crops, is crucial to maintain crop quality and for reducing outbreaks on subsequent crops.

Management: There are several approaches in cultural and biological control that can prevent pest outbreaks as part of an IPM program. Weed management is important to reduce pest buildup on non-crop hosts. Henbit, for example, was found to harbor aphids on several farms in Indiana during winter production of leafy greens. It is currently unclear which weed management strategy effectively removes pests while having minimal impact on natural enemies on weeds. Exclusion netting can be an effective tool to reduce infestation by flea beetles, tarnished plant bug, and other common insect pests, but can negatively impact ventilation and limit crop growth and natural enemy survival. Biological control options that can be effective under high tunnels include entomopathogenic nematodes (for fungus gnats in particular) and entomopathogenic fungi (many targets), predators (for aphid and spider mite management), and parasitoids (for whiteflies and aphids). High tunnel plastics, especially those that block UV radiation, are known to improve the efficacy of many pesticides and biopesticides. Thus, care should be taken to follow label instructions and to not over apply.

Ingwell, L., Thompson, S.L., Kaplan, I., and Foster, R.E. 2017. High tunnels: protection for rather than from insect pests? Pest Management Science, 17 (12): 2439-2446.

Dr. Samantha Willden is originally from the deserts of southern Utah. She received her B.S. and M.S. degrees at Utah State University where she was exposed to insects, and their important role in agricultural systems. Dr. Willden moved to upstate New York to gain more experience in specialty crop production and pest management under the supervision of Dr. Gregory Loeb. She received her PhD in Entomology from Cornell University in 2022. She is currently a postdoctoral researcher at Purdue University working with Dr. Laura Ingwell on specialty crop production under high tunnels. Her primary work is focused on biological control and developing new tools for pest management on urban farms.

DETECTING AND COMBATING HIDDEN DISEASES IN HIGH TUNNEL TOMATO PRODUCTION

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What are soilborne diseases?
It is easy to see when plant diseases impact leaves or fruits, but it is more difficult to detect the hidden diseases that impact the less noticed parts of plants including roots, crowns and stems. Diseases that impact roots, crown and stems are often caused by soilborne pathogens. These soilborne pathogens produce survival structures that last for many years. Soilborne pathogens spread on tools, boots, equipment, and water if they are contaminated with infested soil. Oftentimes, soilborne pathogens infect a wide range of vegetable hosts meaning that even if a high tunnel grower is rotating vegetable crops, the pathogens may keep feasting on roots, crowns and stems. Soilborne diseases are often noticed only after they cause massive damage to roots, crowns, or stems and foliage finally starts to show these stresses. Aboveground indications of soilborne diseases include stunting, wilting, yellowing, dieback, and smaller fruits.

Why are these soilborne diseases an issue in high tunnels?
Soilborne diseases are especially problematic in high tunnels due to a lack of rotation options, a warmer, protected environment within tunnels, and their hidden nature. It is not unusual for growers to grow tomato in high tunnels for years without rotation, and this leads to a constant growth of soilborne pathogen populations. As soilborne pathogens have wide host ranges, they are able to infect and reproduce on most vegetable crops. This means that even with crop rotation, soilborne pathogens will build to damaging levels within a tunnel. The warmer, protected environment within high tunnels allows these pathogens to survive for long periods of time whereas in open fields in cold climates, hard winter freezes reduce soilborne pathogen survival. Soilborne diseases are often not noticed until they greatly impact plant growth and at this point, managing these diseases can be difficult due to the amount of pathogens in the soil.

Which soilborne diseases are issues in high tunnels?
Soilborne diseases can occur on their own, but often, two or more soilborne diseases are identified in a high tunnel. Multiple diseases occurring together are called disease complexes. Common high tunnel diseases include fungal wilts, Fusarium wilt *(Fusarium oxysporum* f.sp. *lycopersici)* and Verticillium wilt *(Verticillium dahliae)*, fungal root rots, corky root rot (*Pseudopyrenochaeta lycopersici* and *Pseudopyrenochaeta terrestris)* and black dot root rot *(Colletotrichum coccodes)*, damping off (caused by various oomycetes and fungi), white mold (*Sclerotinia sclerotiorum)*, and root-knot nematodes.

In surveys in Ohio high tunnels in 2017 and 2022, these diseases were found quite frequently. In the 2017 survey, which included 71 high tunnels on 36 farms, the corky root rot pathogen was identified in 46% of high tunnels and 50% of farms. The black dot root rot pathogen was identified in 90% of high tunnels and 97% of farms. The Verticillium wilt pathogen was detected in 48% of high tunnels and 75% of farms. Root-knot nematodes were detected in 45% of high tunnels and 56% of farms.

Anna Testen is a Research Plant Pathologist with the USDA-ARS Application Technology Research Unit in Wooster, OH. Her research focuses on developing sustainable methods of disease management for specialty crops in controlled environment agriculture. She earned a Bachelor's degree from the University of Minnesota in microbiology and environmental horticulture, a Master's from Penn State in plant pathology and international agriculture and development and a PhD from Ohio State in plant pathology.

In the 2021 survey, which included 62 high tunnels from 22 farms, the corky root rot pathogen was found on 72% of farms and 66% of high tunnels. The black dot root rot pathogen was found on 86% of farms and 80% of high tunnels. The Verticillium wilt pathogen was identified on 81% of farms and 87% of high tunnels, while root-knot nematodes were detected on 90% of farms and 77% of high tunnels.

What symptoms should you look for on plants affected by a soilborne disease?
Taking a closer look at roots, crowns, and stems during and after the growing season can help growers to identify potential soilborne disease issues. Roots, crowns and stems can provide clues that they are being attacked by soilborne diseases. Healthy roots are white to ivory in color, have a strong taproot, grow vigorously, and have many lateral and feeder roots. Healthy crowns and stems are firm and show no discoloration. Diseased roots can be golden, brown or black in color, have changes in texture including being soft or barky, be reduced in size and lack fine roots, and have galls or club-like growth. Diseased crowns may appear girdled or discolored at the soil line and internal discoloration may be present. Diseased stems usually exhibit brown discoloration that indicates a pathogen is clogging the water and nutrient transmitting vessels.

Approaches to manage soilborne diseases in high tunnels
When managing soilborne diseases, growers should use approaches that keep existing pathogen populations from increasing and approaches that actively reduce existing population levels. General approaches to maintain good soil health should also be used. These include adding organic matter to soil, reducing compaction, and improving soil drainage. These approaches will improve general plant health as well. Disease management approaches to prevent increases in soilborne pathogen populations include sanitation and removal of as much infected root, crown and stem material as possible, rotation, use of resistant varieties, and grafting onto disease resistant rootstocks. Disease management approaches that actively reduce existing pathogen populations include fumigation, steam sterilization, solarization and anaerobic soil disinfestation. Of these, anaerobic soil disinfestation is a realistic management technique for most high tunnel growers.

How to apply anaerobic soil disinfestation
Anaerobic soil disinfestation is a biological method of soilborne disease management in which soils are amended with a carbon source, such as wheat midds or molasses, irrigated to saturation, and covered with a plastic mulch for several weeks. Native soil microbes use the added carbon source as food and use up soil oxygen in the process. As the carbon source is next broken down anaerobically (without oxygen), waste byproducts are produced that decrease soilborne pathogen populations. This process has been consistently used to reduce damage from root-knot nematodes, Verticillium wilt, corky root rot and black dot root rot. Most high tunnel growers in temperate regions may consider a September or October ASD application. Spring applications may also be made but would delay high tunnel planting.

For growers applying anaerobic soil disinfestation, they should consider the three steps of the process when adapting to their production practices. Growers can use ASD to treat either beds or flat ground.

For carbon sources, growers should look for a locally available, inexpensive agricultural byproduct that can easily be broken down by soil microbes. Wheat midds, wheat bran, soybean meal, molasses and distillers dried grains have all been shown to reduce disease. These carbon sources are applied at rates of 6-9 tons per acre. The most consistent carbon sources in Ohio studies are wheat bran or midds at 9 t/a or a combination of wheat bran/midds at 9 t/a with molasses at 4.5 t/a. Carbon sources should be evenly spread over the area to be treated and incorporated to a depth of 6-8 inches. If molasses is used, it should be diluted and poured evenly over the soil surface. Molasses does not need to be tilled into the soil.

For irrigation, soil should be saturated to a depth of 6-8 inches with either overhead or drip irrigation. If the treated soil drains very quickly, additional irrigation may be required to keep soil at field capacity.

Soil should then be tarped with a heavy plastic mulch, silage tarp, or construction sheeting. Either clear or black plastic can be used. The edges of the plastic should be buried or covered to prevent air exchange. High tunnels should be sealed to increase soil temperatures. Soil temperatures should remain about 68°F for the first two weeks of treatment to improve efficacy. The warmer the soils are, the better results will occur. Plastic should remain in place for 4-6 weeks.

The plastic should be removed or holes cut into the plastic to allow the soil to breathe and dry out for one week prior to planting. Soil fertility should be checked prior to planting and planting can then occur as usual. If disease pressure is high, growers may consider applying ASD in two consecutive growing seasons. Once soilborne diseases are in check, growers should consider ASD treatments every 3-5 years.

Resources to learn more about tomato soilborne diseases and anaerobic soil disinfestation
The Vegetable Beet Podcast "Knocking the wind out of soil diseases"
https://share.transistor.fm/s/ab280350
Anaerobic soil disinfestation Virtual Workshop, Central State University and USDA-ARS
https://www.youtube.com/watch?v=w7klEVwMGUM
Factsheet about ASD in vegetable production
https://ohioline.osu.edu/factsheet/hyg-3315
Factsheet on soilborne diseases of tomato
https://ohioline.osu.edu/factsheet/hyg-3314

SOIL FERTILITY MANAGEMENT POST ANAEROBIC SOIL DISINFESTATION IN HIGH TUNNEL PRODUCTION SYSTEMS

Francesco Di Gioia, Luca Passerini, Raymond Balaguer
Department of Plant Science, Pennsylvania State University.

The adoption of intensive crop cultivation practices and tomato monoculture in high tunnel production systems is leading to the emergence of a series of soilborne pest and pathogen issues that can cause a substantial decline of crop productivity. Emerging soilborne pests and pathogens observed in high tunnels in the Mid-Atlantic region include plant damaging root-knot nematodes and fungal pathogens such as Fusarium wilt, Fusarium crown and root rot, Corky root rot and Verticillium wilt. Some of these soilborne pathogens have a wide range of hosts, however, tomato monoculture can favor their incidence and severity, contributing to build-up inoculum year after year. To avoid or limit the occurrence of such soilborne issues it is essential to implement adequate soil management and disinfestation strategies. Anaerobic Soil Disinfestation (ASD) is increasingly proposed as a biological approach for the management of soilborne pests and pathogen issues and is one of the few sustainable approaches applicable in high tunnels in the Mid-Atlantic region. As an amendment-based pre-planting soil disinfestation method, ASD is applied by 1) amending the soil with organic amendments that are easily decomposable by the soil microbial communities; 2) mulching the soil with an impermeable film such as totally impermeable film (TIF); and 3) irrigating the soil to field capacity. The incorporation in the soil of an easily decomposable organic amendment (essentially a source of easily decomposable carbon or sugar) stimulates a rapid growth of the endemic soil microbial communities which leads to the rapid depletion of oxygen in the soil and the development of anaerobic conditions. The use of an impermeable film and the irrigation of the soil to field capacity contribute to the rapid develop and maintain anaerobic conditions for a one or two weeks. As the soil shifts from aerobic to anaerobic conditions there is also a shift of the predominant microbial population and the organic amendment incorporated in the soil is decomposed through a sort of fermentation process. The fermentation of the organic amendment incorporated in the soil leads to the production of organic acids and volatile organic compounds that can suppress soilborne fungal and bacterial pathogens, root-knot nematodes, and even weeds. After the rapid decomposition of the organic amendment, the soil gradually returns to aerobic conditions and after 3-4 weeks a new crop can be planted. The selection of the organic amendment (carbon source) used to initiate the ASD treatment is critical non only for the suppression of soilborne pests and pathogens, but also for the impact on the availability of nutrients for the crops following the ASD treatment. Understanding the factors that affect the availability of nutrients following the ASD treatment is key to avoid any negative impact on the crop established after the treatment and to define any adjustment of the crop fertilization plan. To this purpose, a series of studies have been conducted to examine the effect of alternative C sources (sugarcane molasses, wheat middlings, and soybean meal) on soil nutrient availability during and after the application of ASD in high tunnel vegetable production systems in Central Pennsylvania. The results of our research suggested that the application rate of the C source and the ratio between C and nitrogen (N) contained in the organic amendment used for the application of ASD have significant effects on the achievement of anaerobic conditions and thus the efficacy of the ASD treatment, as well as on nutrient availability. Soil pH, electrical conductivity (EC) and nitrate availability during and after the ASD treatment were monitored through soil sampling and the 1:2 (v:v) soil water extraction method. Variations of soil pH, EC and nitrate content were observed during and after the ASD treatment. In particular, the availability of mineral-N was influenced by the C source rate and its C:N ratio. Organic amendments characterized by a relatively higher C:N ratio reduced the availability of nitrate-N during the ASD treatment and right after planting compared with organic amendments characterized by higher N content. Besides

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the effect on N availability, the organic amendments used as C source for the application of the ASD treatment provide several other macro and micro-nutrients and their composition is reflected in the availability of nutrients for the crop post-ASD. These results suggest that the C sources used significantly affect the availability of nutrients and crop fertilization should be adjusted accordingly. Mineral N levels, and particularly soil nitrate levels should be assessed at the end of the ASD treatment and a supplemental N application may be needed if high rates of C are used or if the C source used have a high C:N ratio. For other nutrients, fertilization should be reduced considering the amount of macro- and micro-nutrients applied with the C source. In high tunnel production systems, which are prone to the accumulation of nutrients that are in excess, the impact of the C sources on nutrient availability should be taken in due consideration to avoid any excess of nutrients and the buildup of soil salinity which could be detrimental for the crop. On the other hand, the positive fertilization effect of the organic amendments should be accounted in evaluating the economic viability of the ASD treatment, considering that the availability of some nutrients may be improved for over one growing season.

Acknowledgements

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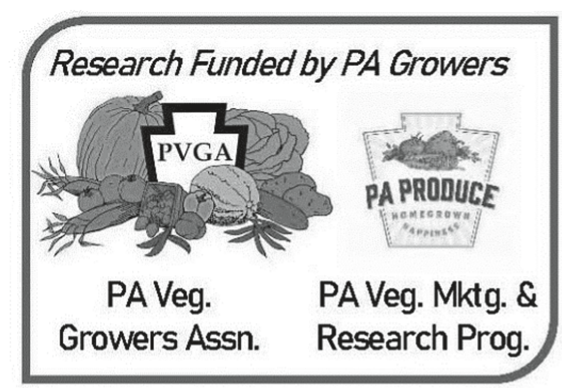

CULTURAL CONTROLS FOR PHYTOPHTHORA CAPSICI WITH AN EMPHASIS ON WATER MANAGEMENT

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As we see wetter weather patterns, Phytophthora blight caused by *Phytophthora capsici* (P. cap) can become a major limiting disease in vine crops, peppers and tomatoes. P. cap is not a fungus – it belongs to a group of organisms called Oomycetes which are more closely related to algae than fungi. Oomycete specific fungicides help control this disease in field grown crops grown on bare ground such as cucumbers, pumpkins, and lima beans. However, due to the nature of the plasticulture growing systems used in vine crops such as watermelons and cantaloupes, with much of a field in impervious plastic, water collecting between the rows allows for the disease to proliferate and spread rapidly when multiple inch rainfalls occur.

Vine crop fruit can become infected at any stage of maturity, either from direct contact with the soil or from splashing rain. Initially, symptoms will appear as small water-soaked areas that quickly enlarge and can become covered in sporangia in high humidity. Sporangia-covered lesions will have a gray to white appearance. The rot will develop rapidly until the fruit is completely collapsed.

P. capsici has two mating types (called A1 and A2) that are genetically distinct. When both mating types are present in one field, they mate to produce survival structures called oospores. Oospores can survive in the soil for many years and provide the initial inoculum for disease initiation when conditions become favorable. The asexual stage of P. capsici, which is responsible for initiating infection, depends on water for infecting and moving between plants. Disease will almost always begin in low spots of fields or in areas that do not drain readily, such as row middles. When contaminated soils are saturated for several hours and temperatures are relatively warm, P. capsici will form structures called sporangia. Sporangia can directly germinate to cause disease; however, they also contain asexual, swimming zoospores that are released into the saturated soil in wet conditions. Zoospores are attracted to living plant parts in the soil and on the soil surface and swim toward them. Once they find a host plant, zoospores can germinate and infect any plant part, but in the case of watermelons, fruits readily become infected.

Oospores are spread from field to field in infested soil adhering to machinery or humans. Zoospores are spread primarily splashing water from rain, or water running through fields during rain events. If contaminated field runoff drains into an irrigation pond, that irrigation pond may become a source of inoculum and spread the pathogen throughout the crop or onto other fields.

As stated before, Oomycete specific chemicals will not fully control P. cap in vine crops. This is because once the fruit sets on the ground, the chemicals cannot reach that part of the fruit. Research has also shown that applications through the drip system are not effective at controlling the fruit rot phase of the disease. Continue foliar applications and start at first fruit set.

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On a positive note, resistance to P. cap has been found in watermelon germplasm and breeding lines have been released from the USDA research program in Charleston S.C. (see https://cuccap.org/breeding/watermelon/#phytophthora) However, it will take several years to get this resistance into commercial varieties. P. cap resistance is also available in some bell pepper varieties

Current chemical control recommendations are shown below for watermelons, other crops may have different chemicals labelled:

Code	Product Name (*=Restricted Use)	Product Rate	Active Ingredient(s)	PHI (d)	REI (h)	Bee TR
Apply one of the following fungicides and tank mix with fixed copper at labeled rates when conditions favor disease development (for suppression only). Materials with different modes of action (FRAC codes) should always be alternated to reduce the chances for fungicide resistance development:						
49 + 40	Orondis Ultra 2.33SC	5.5 to 8.0 fl oz/A	oxathiapiprolin + mandipropamid	0	4	--
49+M05	Orondis Opti[1]	1.75 to 2.5 pt/A	oxathiapiprolin + chlorothalonil	0	12	--
40	Revus 2.08F	8.0 fl oz/A	mandipropamid	0	4	--
40 + 45	Zampro 525SC	14.0 fl oz/A	dimethomorph + ametoctradin	0	12	--
43	Presidio 4SC[2]	4.0 fl oz/A	fluopicolide	2	12	L
M03+22	Gavel 75DF	1.5 to 2.0 lb/A	mancozeb + zoxamide (**note**: some cultivars are sensitive to mancozeb)	5	48	--
21	Ranman 400SC	2.75 fl oz/A (**Do not apply with copper**, see label for details)[2]	cyazofamid	0	12	L
40	Forum 4.17SC	6.0 fl oz/A	dimethomorph	0	12	N
22	Elumin 4SC	8 fl oz/A	ethaboxam	2	12	--
M05+22	Zing! 4.9SC[1]	36.0 fl oz/A	chlorothalonil + zoxamide	0	12	N

[1]Tank mixes of additives, adjuvants, and/or other products may result in crop injury.
[2]Presidio may also be applied through the drip irrigation (see supplemental label).
[3]Ranman should be tank mixed with an organosilicone surfactant when disease is severe, or a non-ionic surfactant or blend of organosilicone and non-ionic surfactant disease is moderate or light.

Growers must also use cultural controls to manage this disease. The following are guidelines for cultural control of Phytophthora blight in watermelons:

1) Practice long rotations in fields with a history of P. cap infections. Plant non-host crops such as corn, small grains, soybeans, or brassicas in these fields for at least 3 years (4-5 years would be ideal). Remember that P. cap infects tomato, pepper, eggplant, watermelons, cucumbers, squash, pumpkins, melons, lima beans, snap beans and a number of weeds such as purslane, black nightshade, and Carolina geranium. Use P. cap resistant varieties if available (currently in some bell pepper varieties).

2) Avoid introducing Phytophthora into uninfected fields. After working in Phytophthora-infested soil, wash soil from equipment. Always work in clean fields before working in infested fields.

3) Water management: Phytophthora requires saturated soils for infection. Use the following methods to encourage drainage and avoid prolonged soil saturation.

- Be careful to not overwater and check irrigation system regularly for leaks and fix them.
- Break up hardpan and encourage drainage by using a V-ripper or other sub-soiling tool in row middles. Do this pre-planting and as needed during the season.
- Avoid soil compaction. Use farm machinery as little as possible throughout the season and never work in fields when the soil is wet.
- Make sure water can flow out of the field. Create breaks in raised beds and clear away soil at the ends of rows to prevent damming.
- Leave windbreak stubble between each row to reduce splash dispersal of inoculum. Inoculum can move rapidly across plastic mulch and bare soil.
- Shape row middles in a V pattern so that water drains to the middle.

4) Limit impervious surfaces (plastic mulch covered area)

- Use narrow width plastic mulch in high, dome-shaped raised beds of at least 9 inches.
- Increase row width. Avoid 6-7' rows and switch to 8-10' row widths

5) Consider systems that leave plant residue or cover in the row middles

- Consider mulch based no-till systems for later plantings that do not use plastic mulch
- Use every row rye windbreaks that are planted early to give the most mulch after rolling in the growing season.
- Consider living mulch row middles. We are experimenting with ladino clover row middles that stay throughout the season.

If Phytophthora losses become high because of the heavy rains, pre-emptive cultural practices need be taken immediately. Rogueing out, discing under, or hitting areas with Gramoxone to burn infected plants down will help slow down and reduce the spread of potential inoculum to healthier areas of the block or farm. If beds are chronically wet, plastic can be cut or completely removed to help soils dry out.

COLE CROP CATERPILLARS AND OTHER INSECTS

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The ecology and diversity of cole crop beneficial insects and insect pests needs to be properly understood to minimize insect losses. Lepidopteran caterpillars are the most common group of cole crop insect pests, and includes imported cabbageworm, cabbage looper, and diamondback moth. Occasionally, other caterpillar species can cause problems, including beet armyworm, corn earworm, fall armyworm and cross striped cabbageworm. Cole crop preferences, thresholds, susceptibility to various natural enemies and susceptibility to insecticides differs among these species. Three other common insect pests that affect cole crops are aphids, flea beetles, and harlequin bugs. A fourth group, the maggots, will only briefly be covered.

Lep thresholds for heading brassicas are generally around 20% infested plants early, but thresholds decrease to 5% infested plants during early head formation. Thresholds for leafy brassicas are 10% infested plants, but this may be lower for processing vegetables. Other considerations include how small the plants are when they become infested and the worm species. For example, cross striped cabbageworm thresholds are 5% infested plants. There may also be differences among varietal blocks. For instance, savoy-type and red cabbages tend to be less preferred when planted near other cabbage varieties. Thus, scouting should be performed for each type or variety separately.

If thresholds are exceeded, selecting effective yet narrow spectrum chemistry is important. There are multiple species of parasitic wasp that affect the common caterpillar species. In a 2022 parasitoid survey, three sites in Virginia and Delaware had greater than 80% parasitism. Parasitism was so great (and other Lep pests not present) that 95% of untreated cabbage heads were considered marketable (other treatments were applied three times at two week intervals (Fig 1). Pyrethroid, carbamate, and organophosphate applications are extremely detrimental to these beneficial wasps. Diamondback moths, beet armyworm, and corn earworm are generally resistant to pyrethroid applications, and pyrethroid use can flare up aphids. Fortunately, there are numerous other modes of action effective on Lep pests, many of which were evaluated in a 2020 spray trial in Georgetown, DE (Fig. 2). Some insecticides have translaminar activity while others are contact. Those that are contact materials tend to have shorter residual activity. Many of the worms in the Proclaim and Torac treatments were small to mid-sized worms because of the long, two week treatment interval. Growth regulators likewise are most effective on small worms. Among the Lep materials, tolfenpyrad and cyantraniliprole were extremely effective against aphids in a 2021 spray trial (Fig. 3).

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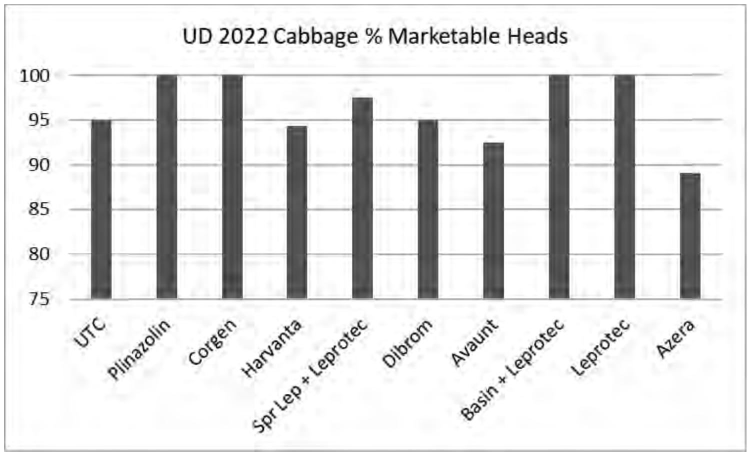

Figure 1. After parasitism destroyed early diamond back moth populations, few heads were damaged by worms in any treatments, including the untreated check in a 2022 spray trial.

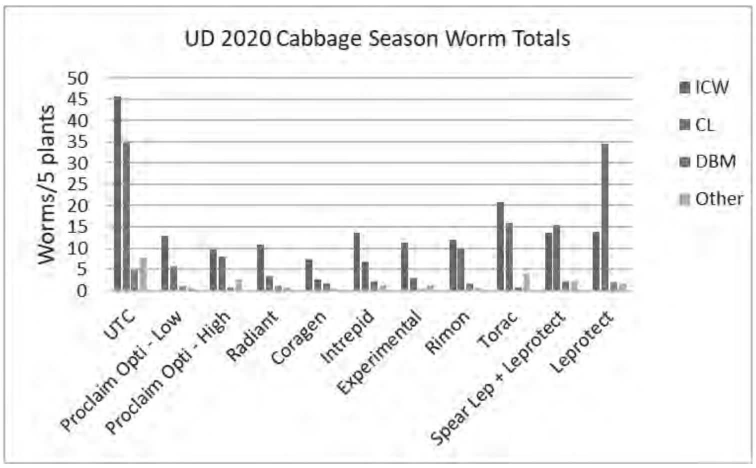

Figure 2. Season worm totals from a 2020 Georgetown spray trial. All treatments significantly reduced worm activity.

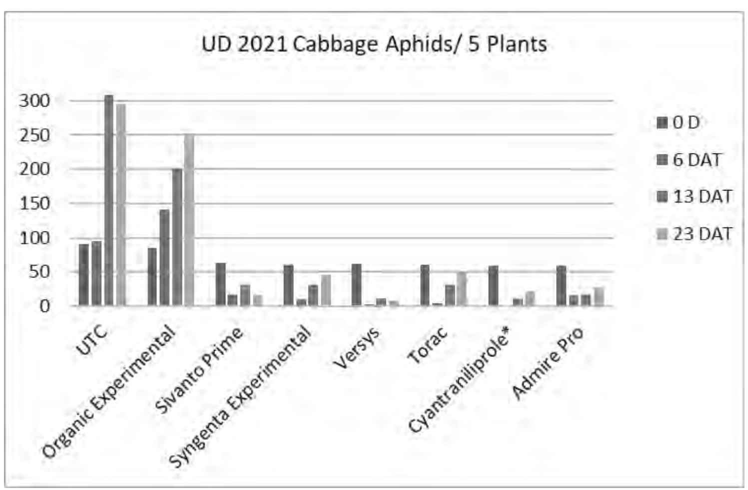

Figure 3. Selected product efficacy against cabbage aphids, including two modes of action that also have worm activity.

Farms with cole crops all season long may need to control harlequin bugs. Virginia Tech research indicated insecticide treated mustard trap crops can concentrate and significantly reduce harlequin bug activity and application foot print. Among the cole crops, harlequin bugs may select particular varieties over others when planted side by side. The most effective harlequin bug materials are pyrethroids (which can be very detrimental to parasitic wasps) and neonicotinoids (which are detrimental to pollinators), although research continues to evaluate materials safer to non-target organisms.

BLOAT NEMATODE AND GARLIC DISEASE MANAGEMENT.

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Bloat nematode: Bloat nematode (*Ditylenchus dipsaci)* has the capacity to destroy garlic crops, and its presence prevents the use of garlic cloves as seed. Following an outbreak on several farms in NY, and in some other northern states in 2010, the nematode has reduced in importance and is now currently a sporadic problem. The main method by which bloat nematode is introduced onto the farm is within garlic seed cloves, which often exhibit no outward symptoms. In climates like NY, the nematode survives winter within soil or within the planted clove. During the growing season nematodes reproduce, and spread to adjacent plants, feeding within young plants and later within the developing garlic bulb. The nematode earns its name from bloat symptoms on leaves and stem of onion, but this symptom is not as evident in garlic. High nematode populations early in the season can cause death of young plants, and later, rotting of garlic bulbs. Individual cloves may contain several thousand nematodes (Fig. 1a). Above-ground symptoms include stunting and yellowing of foliage. The nematode commonly gains entry at the base, and early infestations are seen as a brown discoloration in tissue above the basal plate (Fig 1b). More severe infestations lead to cracking of the developing bulb and loss of roots (Fig. 1c), with root loss sometimes on one side of the basal plate. Infested cloves are often invaded by other organisms, including pathogens such as Fusarium. The main method of control is prevention, so seed should always be sourced from reputable seed suppliers. Once bloat nematode is on farm, a minimum two-year fallow from alliums is advised to reduce populations to low levels. However, the nematode can persist on some weeds. In the past, hot water treatment of seed cloves was used prior to planting. This involved pre-heating of cloves in water at (38°C/30 min.), followed by a hot water/formalin treatment (49°C/20 min.), and a cooling dip (18°C/10 min.). Formalin is no longer registered for this use, and while hot water treatment alone can reduce nematode numbers, it does not usually eradicate them from seed cloves. In our trials, addition of Majestene or Jet-Ag into the heat treatment, or Bleach, Majestene, Trilogy or Agri-Mek in the cooling dip did not increase efficacy over hot water treatment alone. Further, hot water treatment must be undertaken very carefully to prevent damage to the seed cloves. Our trials confirmed that 49°C for 20 minutes was safe for small and large seed cloves of several garlic varieties, but exposure to 50°C for 20 minutes caused a significant reduction in subsequent growth and yield of garlic. Trials in which 50 ml Agri-Mek (1 ml/L), Majestene (0.1-1% v/v) or Trilogy (20 ml/L) were applied to the base of infested plants at three times during the season were also ineffective at reducing nematode numbers in harvested cloves.

Eriophyid mite. Eriophyid mite has become of increasing importance in NY and other northern states in recent years, causing severe losses to some growers (Figure 2). Two species of eriophyid mite, the dry bulb mite, *(Aceria tulipae)* and the wheat curl mite *(Aceria tosichella)* have been reported to attack garlic. Note that eriophyid mites are different to bulb mites which are also often present on garlic, but do not cause direct damage. Planting of cloves infested with eriophyid mite can cause yield loss, and symptoms of leaf twisting, distortion and streaking. However, the most serious issues are commonly in storage. Populations of eriophyid mites can increase greatly after harvest with feeding occurring under the clove husks leading to severe dehydration and discoloration (Fig. 2a), and a sandy texture due to the presence of many adult mites (Fig 2b). Some recommendations for control have been soaking seed for 24 h prior to planting in a 2% soap and 2% mineral oil water bath. Heating of garlic cloves has also been suggested as a useful strategy with eggs killed at 45°C within 1 hour. However, temperatures above 49°C may lead to waxy breakdown, or loss of seed viability.

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Figure 1. Bloat nematode *(Ditylenchus dipsaci)*

a) Bloat nematodes (50 × magnification).

b) Initial feeding causing discoloration at basal region of bulb.

c) Severely affected bulbs exhibiting cracking, basal plate damage, loss of roots and secondary fungal infections.

Figure 2. Eriophyid mite damage.

a) Severe mite infestation with husks peeled away to show discolored cloves.

b) Numerous eriophyid mites feeding on the clove underneath husk

c) Eriophyid mite (400 × magnification)

Our studies have shown dipping mite infested cloves for 10 minutes in M-Pede (1% v/v), or Trilogy (1% v/v), or subjecting cloves to hot water treatment (as for bloat nematode above) resulted in 78.6, 48.6 and 50.0% of cloves with no living mites respectively when observed under the microscope, significantly

better (P<0.001) than the nontreated control in which all cloves had living mites. A field trial in which plants grown from infested seed cloves received basal application of 50 ml of Suffoil-X (0.5% v/v) or M-Pede (0.5% v/v) at three times during the season, resulted in no statistically significant difference in cloves with <1% mite damage in comparison to the nontreated (water only). More work is needed to identify suitable treatments in field and during curing/storage.

Fusarium: Fusarium species are common pathogens causing Fusarium bulb rot (FBR) in the field, and post-harvest bulb and clove rots. In the USA, FBR is caused by Fusarium oxysporum, and F. culmorum. FBR causes pre-emergent decay of garlic seed cloves, chlorosis of leaves, decay of the basal plate, separation of roots or basal plate from the bulb when pulled from the soil, and post-harvest bulb decay. Infected bulbs are brown, soft, and watery when cut open. In addition, stems and developing bulbs of plants infected with F. culmorum may appear red to purple. FBR is favored by warm temperatures (28-32°C), but can occur at 15-32°C. Soil temperatures of 12°C or less, are not conducive to disease development. Late season rains can favor infection in garlic.

Another species, *F. proliferatum*, is mainly associated with 'dry rot' of cloves in storage. Dry rot presents initially as small water-soaked spots on cloves, often hidden underneath the husk. Lesions become sunken, brown, and polygonal-shaped. White mycelia of the fungus develops at an advanced stage of decay. The incidence and severity of clove rot caused by *F. proliferatum* generally increases with storage time, and at a faster rate with storage at room temperature rather than cool storage. Bulbs can appear firm at harvest, but dry rot progresses in storage, leaving cloves shriveled and empty. Although recognized mainly as a post-harvest issue, overseas research has shown inoculation of seed cloves with F. proliferatum also reduced emergence and caused wilt symptoms in the plants that survived. Our studies have shown the most common species associated with clove rot in NY are F. *oxysporum, F. proliferatum* and F. *acuminatum.*

Management strategies for Fusarium include selection of well-drained soil, selection of healthy seed cloves, optimal agronomic practices (i.e., irrigation, fertilizer and weed control), care to avoid damage to bulbs at harvest, and optimal conditions to ensure timely curing. Fungicides applied as a pre-plant dip to seed cloves have shown some promise for Fusarium bulb rot control. A four-year rotation away from allium crops is often recommended for control of *F. oxysporum*. However, the presence of *Fusarium spp.* with broad host ranges, associated with clove rot in garlic in NY and potentially other States, makes the identification of suitable rotation crops for disease management challenging. For example, *F. proliferatum* and *F. acuminatum* cause root rot on common rotational crops used in NY, including soybean or corn. Crop rotation is also not completely effective due to the long-lived nature of Fusarium in soil, and the ability to survive on roots of symptomless alternative hosts.

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FARM FRESH

BEST PRACTICES FOR GREAT GARLIC

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There is an increase in interest in growing garlic in our region and the time to plant garlic is in the fall. The following information is on producing garlic.

Obtain the best strains of Italian or German "Rocambole" garlic (late or pink-skinned type), Porcelain types, Polish softneck types that will braid (no hard seed stalk), or elephant types from a reputable agriculture products vendor or a local grower who has had success with fall-planted garlic. A locally grown strain will be hardy and may overwinter better than many commercially available strains.

In our region, the hardneck varieties Music, Spanish Roja and Carpathian have performed well. Oher hardneck varieties include Penn Wonder (Amish), German Red, Bavarian Purple, Marino, Russian Red, Calabria, Hungarian Purple, Romanian Red, German Extra Hardy, Georgian Fire, Georgian Crystal, Armenian and Zemo.

Avoid Creole garlics (also called Early, Louisiana, White Mexican, etc.), since they are not very winter-hardy and do not keep well. Bulbs of both Creole and Italian/German garlic have a white outer skin, but the Italian or German types have a pink skin around each clove. Elephant garlic (Allium ampeloprasum) is a type of leek that produces bulbils, is milder than regular garlic, and up to four times larger. However, Elephant garlic may not yield well when fall-planted in areas with severe cold or extensive freezing and thawing cycles, which cause heaving. The Italian/German and Elephant types take about 220 days to mature.

Many of the most productive Italian or German garlic strains will produce seed stalks (scapes) prior to harvest. It is important to cut these seed stalks off just as they begin to coil for highest yields with good flavor. Scapes can be sold as a specialty item with garlic flavor. "Rocambole" types have coiled seed stalks that are perfectly normal and not the result of any poor cultural practice or herbicide contamination. Use sharp scissors to cut the scape as close to the base of the plant as you can without removing any leaves. Scapes do not all appear at once, so it is necessary to continue scouting for scapes as garlic matures.

Garlic has a moderate nitrogen requirement (125 lbs/a total during the growing season) and higher phosphorus and potassium requirements (150 lbs/acre respectively).

Garlic cloves should be planted in early November on Delmarva and in mid-October further north and west. Growers should plant as late as possible to escape damage from the fall generation of the allium leafminer if present in the growing area. Yield tends to increase with the size of the mother bulb. Do not use the following for planting: long, slender cloves in the center of the bulb, cloves weighing less than 1 gram, or bulbs with side growths and very poor skin covering of cloves.

Garlic must be exposed to temperatures between 32-50°F (0-10°C) for about 2 months prior to the long daylength periods that induce bulbing. Fall-planted garlic establishes an excellent root system and receives a natural cold treatment that produces the highest possible garlic yields. Spring-planted garlic (e.g., Elephant type) may be successful where it can be planted by early March.

Cloves should be planted 4 by 4 inches apart in triple rows or multiple beds 16-18 inches apart. Between-row spacing

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depends on equipment available. Clove tops should be covered with 1-1½ inches of soil. Cloves must not be so deep that the soil will interfere with the growth of the bulbs, nor so shallow that rain, heaving from alternate freezing and thawing, and birds may dislodge them. Cloves placed with the root end down give optimum results. Cloves dropped into furrows will be in various positions and may produce plants with crooked necks.

Fall-planted garlic is ready for harvesting about the second week in July when 40-60% of the leaves have yellowed (garlic generally has 6 leaves). When plants reach this stage pull a sample. There are only about 10- 14 days for optimum harvest, when each clove is fully segmented and yet fully covered by a tight outer skin. Before the optimum harvest time, garlic is unsegmented like an onion. After the optimum time, cloves may have separated, the outer sheath split, and part of the naked cloves may be exposed. Run a cutter bar under the bulbs to cut the extensive root system and partially lift the bulbs. Bulbs can be pulled and gathered into windrows. Tops are placed uppermost in the windrow to protect bulbs from the sun. Garlic is left in the field for a week or more to dry or cure thoroughly. Curing can also be accomplished in a well-ventilated shed or barn. Use this option when rain is forecasted. Bulbs must be thoroughly dried before being shipped or stored. After curing, remove the outer loose portions of the sheath, and trim the roots close to the bulbs. Braid or bunch the tops together or cut off the tops and bag the bulbs like dry onions. Discard diseased and damaged bulbs.

When properly cured, garlic keeps well under a wide range of temperatures. Temporary storage in open-mesh sacks in a dry, well-ventilated storage room at 60-90°F is acceptable. However, storage at 32-35°F and 65% relative humidity (the same conditions as required for onions) is best. Avoid prolonged storage near 40°F to prevent sprouting of cloves. Avoid a relative humidity above 70% to prevent sprouting and development of mold.

Prefar is the only preplant/preemergence herbicide labeled.

Pests include the Allium leafminer, bloat nematode, and the diseases Botrytis leaf blight, downy mildew, Fusarium rot, purple blotch, and white rot. See the Mid-Atlantic Commercial Vegetable Production Recommendations for specific control recommendations.

THE PROMISE AND REALITIES OF URBAN AGRICULTURE

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As urban farms have proliferated around the United States in the past decades, much attention has been paid to their youth engagement, community development, educational and other social impacts. Commercial-focused urban farmers may have many social and community goals as part of their mission but they seek to primarily support their farms through sales of agricultural products. Yet there have been few assessments of how commercial urban farms, which face the narrow margins and high risks of growing produce in small spaces, can thrive based on primarily sales of their products. While there are some emerging sectors in commercial urban farming that are highly capitalized (e.g. controlled environment agriculture, vertical farming), most soil-based urban farms face many of the same challenges as rural small farms.

The Study

The 2019 publication, "The Promise of Urban Agriculture," summarizes the journey of 14 urban farmers and insights from over 150 policy-makers, urban planners, funders, and nonprofit and community organizers engaged in local food systems and urban farming to uncover the policies, resources, and future research and development needed to support the development of commercial urban farms.

Though the case study farms and others profiled in the report were diverse in their structures and operations, their stories illustrate key requirements to reaching commercial viability:

1. Obtaining access to affordable, usable land for agricultural purposes is a cost-prohibitive barrier to entry for many prospective urban farmers, especially those seeking financial self-sufficiency. The ability of urban farms to maintain access to land over time is often threatened by rising land values and real estate development pressures. Those urban farms that have been successful in acquiring long-term access to land that supports commercial production frequently obtained their access to land through exceptional circumstances.
2. Commercial urban farms often depend on revenue-generating activities beyond agricultural sales to sustain themselves financially, including agritourism, consumer workshops, and events.
3. Commercial viability for urban farms depends upon continued demand for local food through farmers' markets, CSAs, and locally-focused restaurants and retailers, as commercial urban farms cannot typically compete on price point alone.

Dr. Anu Rangarajan has been on the faculty of Horticulture at Cornell University since 1996, serving as a fresh market vegetable production specialist. She also directs the Cornell Small Farms Program and serves as an Assistant Director of Cornell Cooperative Extension. The Small Farms Program has the mission to help any farmer get expert assistance to facilitate all phases of small farm business development, from startup to growth to maturity. She applied the lens of commercial small-scale farming to understand conditions that allow commercial urban small farms to thrive. These research findings are published in "The Promise of Urban Agriculture." The findings are now being transformed into curricula for experienced growers seeking to farm in urban spaces as well as planners and policy makers interested in supporting urban agriculture development. She is also part of a team creating workforce development training for controlled environment agriculture.

Molly Riordan has been an Urban Agriculture Specialist with Cornell Small Farms Program since 2015, supporting its urban agriculture research and technical assistance. A regional planner by training, her work in regional food system development explores opportunities to scale mutually beneficial relationships between farmers, food businesses, institutions, and the community. She is Chair of the American Planning Association's Food Systems Planning Division, and earned her Master of Regional Planning from Cornell University. She lives in Philadelphia.

4. Commercial urban farms are usually social enterprises driven to generate economic revenue and to address community needs. They tend to be very attuned and sensitive to community concerns and feedback, and often feel pulled in different—and incompatible— directions.

5. Commercial urban farms cannot be all things to all people. Farmer profitability is essential for these types of operations to be sustainable and at times this means prioritizing financial objectives over social objectives.

In addition to farm-based findings and recommendations, the study outlines opportunities for local government, nonprofit, and technical assistance and extension actors to support commercial urban agriculture.

Current Activities

Based on the report findings, the presenters, along with colleagues at Rooted (Wisconsin) and Cornell Cooperative Extension with support from USDA Agricultural Marketing Service, are developing a set of online professional development courses to assist experienced farmers in *realizing* the promise of commercial urban agriculture. The courses, to be piloted and launched in 2023, will teach key skills and techniques identified through the report, continuing research, and first-hand experience from successful commercial urban growers.

Additionally, the presenters are developing a professional development course for city and regional planners and food policy professionals to understand the benefits of urban agriculture and how it can best be supported through local and regional policy and programming.

The multi-media courses will feature video case studies and audio stories to bring lessons to life and help participants build connections with their colleagues across the country.

INSECT PESTS AND NATURAL ENEMIES ON URBAN FARMS: WHAT WE CAN LEARN FROM A SURVEY IN INDIANA

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Urban agriculture is an increasingly popular and important contribution to local food systems. Practitioners require production information that is tailored to the type of growing and unique environments in which they operate. Unfortunately, we don't have a solid understanding of these environments, including potential heat island effects on crop growth and insect communities. Therefore, we have made it a priority to identify the community composition of insect populations in urban food systems that can form the foundation of Urban Ag IPM programs and future research. The work that I will be sharing is the result of a study carried out as part of a senior thesis project examining arthropod diversity, feeding guild and predation services within urban gardens across two different counties in central Indiana.

The study occurred at 10 urban gardens/farms in the summer of 2021. The size of the farms ranged from 600-10,000 sq. feet and produced a diversity of crops in or near a city center. Active and passive sampling as well as visual observations were made at each location in June, July and August. An inventory of the plant types and density was recorded at each location, as well as growing practices and ground cover (plastic mulch, wood chips, etc.). The goal of this work was to identify and quantify arthropods encountered at each location and begin to develop potential food webs by characterizing the organisms based on taxonomic identification as well as feeding guild association. Sentinel prey items were also deployed to measure pest control services across space and time.

Some of the most interesting findings from this study revealed that despite location, herbivores were most abundant on zucchini crops and omnivores most abundant on melon; there were no differences in predator abundance during visual surveys among any of the crop types. The highest diversity of arthropods was seen through visual surveys at a garden site in Montgomery County and the lowest diversity recorded in pitfall traps collected at a site in Tippecanoe County. The sentinel prey experiments showed that aphid parasitism peaked during the month of August. We did not detect *Manduca sexta* parasitoids, but rather attribute their predation to direct consumption. We recorded predation rates of *Helicoverpa zea* eggs ranging from 43-73% over a 48-hr period.

This work continues to identify the species collected and examine abiotic and biotic site characteristics that may help explain differences in the community composition that were observed. Our future work will aim to examine the most abundant herbivores and determine their phenology and natural enemies present in the urban landscape.

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.

LESSONS LEARNED: LARGER SCALE URBAN SOILS REMEDIATION

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A myriad of conditions and variables will impact remediation of large scale urban farming operations. While each farm will face different challenges in their efforts to remediate soil, there are considerations and actions which can generally help guide a remediation timeline and process. Since beginning operations in 2019, Hilltop Urban Farm (HUF) has made significant strides in basic soil remediation efforts while simultaneously meeting important programming, production, and organizational goals. To understand HUF's remediation strategy and challenges, context regarding broader conditions impacting the site and the organization is required.

Property and organizational history, site conditions

HUF is located on 23 acres of a 107 acre parcel in the southern hills of Pittsburgh PA. As late as the 1950's, the property was home to several family farms and residential units. From the early 1950's thru 2010, the property was home to a housing complex (St. Clair Village). At its peak, St. Clair Village consisted of 70 multi-family housing structures that 1,089 families called home.

When the last of the buildings were demolished in 2010, former residents, neighbors and local concerned citizens groups organized planning efforts which led to the formation of the HUF. Led by the Hilltop Alliance, several highly regarded and skilled partners were enlisted to develop plans for the site, including a soil rebuilding plan. After several years of community input, feasibility plans, site master plans, operational plans and creating a new free-standing non-profit organization to manage the farm, operations and programming began in spring 2019.

As the location of a former federal housing development, the site is still owned and controlled by the Housing Authority of the City of Pittsburgh (HACP). The plan is for an Allegheny County-based nonprofit (Allegheny Land Trust) to eventually purchase the property and enter a long-term lease arrangement with HUF. Until this transfer takes place, HUF operates under an annual lease agreement with the HACP.

The annual lease agreement contains conditions which impact all aspects of organizational development, including soil remediations. Some of the more impactful conditions include Prohibition of building permanent structures, no access to electrical grid, limited access/service to basic water utility services and the gates to the site must be under lock and key 24 hours per day. Operating under an annual lease agreement also raises challenges regarding long-term infrastructure investment for the organization and for the farmers who lease production space at the farm.

Another factor which significantly impacts soil remediation plans includes the enormous quantity of rock, rubble, concrete, cables, piping, and other man-made materials left behind when the buildings that once occupied the site were demolished. In 2022 alone, a conservative estimate is that over 300,000 pounds of these materials were exposed and removed from the site. It's estimated that since 2019, between 750-850,000 pounds of rubble has been removed. Addressing this problem is exponentially compounded by the severe soil compaction of much of the site.

Understand where soil remediation fits in with broader organization goals and responsibilities.

The remediation of soil at HUF is an immense undertaking that will consume time, resources, and planning for years/decades to come. The reality for HUF is, while soil remediation is a fundamental building block for the farm, it is only one of many priorities that must be addressed to achieve organizational goals. While the organization invests

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substantial time and effort into initial, basic, physically-demanding remediation efforts, HUF must also invest time in running a accountable and fiscally responsible organization, plan for and deliver programming (HUF currently offers Youth Farm Programming and Farmer Incubator Programming) agricultural production (staff-managed Community Farm plot which provides fresh produce to Hilltop-serving food pantries and management of 250 fruit tree orchard planted in the last 4-5 years) and providing/maintaining solar powered electric and water service to the farm. An overarching goal of the farm is to directly serve the Hilltop community where the farm is located. The Hilltop is considered a food desert and has often been overlooked and under-served.

Plan and manage soil remediation goals to synch with broader organizational, programming and production priorities.
HUF has big plans and an incredible amount of potential. While it is exciting to launch a new, large urban farm with so many possibilities, it is equally important to manage expectations. Hilltop Urban Farm is deeply committed to serving the community around the farm. In addition to serving the community, HUF also has responsibilities to its funders, partners, and program participants.

While conditions will vary between large scale urban farming efforts, HUF recognizes it can't do everything at once. HUF has not had the luxury of solely focusing on soil remediation prior to beginning operations, The organization realizes that it must plan and implement complimentary efforts to make strides towards its goals. When it comes to soil remediation-related efforts, it's best to give yourself as much lead time as possible and to identify, and meet, specific soil remediation goals that will allow expected progress in other priority areas.

For example, of the many programs/projects envisioned and planned for HUF, the organization started by offering Youth Programming and a Farmer Incubator Program. Since the designated Youth Farm area is in an area with large stretches of shallow natural rock formations, raised beds were erected to provide the main growing/demonstration areas for the Youth Farm and soil remediation was not a factor.

Conversely, the area designated for the Farmer Incubator Program (FIP) requires a high level of soil remediation. Basically, the FIP offers approved participants ¼-acre plots with water to each plot, shared tools and implements and modest training opportunities. It's been common to remove 30,000-40,000 pounds of rock and rubble from individual quarter acre plots before participants can consider any sort of crop production.

While a soil remediation plan existed, no one was ready for the level of rubble and compaction that needed to be addressed. The farm initially did not have access to the right equipment or the adequate level of staff to tackle the physically demanding work to assist in clearing the plots for the incubator program. The first year of the incubator program was a humbling experience but the organization quickly responded and have put all program participants in a position to succeed.

Implementation of Soil Rebuilding Plan – Be Flexible
The first recommended step of the original soil rebuilding plan called for all land that would eventually be put into production to be subsoiled at a depth of 20-36" to allow water to deeply penetrate the soil profile and to stimulate plant root growth and soil ecology. This was to be completed before any other soil remediation work was to begin.

Several factors led to the HUF management team amending this plan. Initial attempts to subsoil large tracts of land exposed several issues that needed to be addressed. First, the subsoiling exposed massive amounts of concrete and bricks, leaving deep subsoil trenches that were lined and covered with bricks. Any cover cropping and growth from volunteer vegetation in these areas would soon cover all the exposed rubble and would require the use of additional heavy equipment, which would begin to recompact the soil, to re-expose and remove the rubble from the site.

It was decided that rather than trying to subsoil all the soil at once, that HUF would begin soil rebuilding in smaller plots (1/4 – 1.25 acres plots). In some cases, HUF would take several passes with a BCS walk behind tractor with rotary (groundbreaker) plows, and then use a subsoiler attachment, to break the soil and in other instances had to resort to contracting to have a bulldozer with rippers set at 24" to go through the fields. In some cases, even the 100 hp bulldozer was brought to an abrupt stop or completely turned sideways. The bulldozer hit several 2'x4'x4' concrete blocks that had multiple rods of rebar connecting the blocks together that were only 4-6 inches below the soil surface. The bulldozer/ripper got tangled in heavy gauge braided steel cables and collided with concrete enforced drainage culverts.

HUF would try to line up volunteer groups to assist with the rubble removal immediately after running equipment through the soil to expose what was left behind. It was important to remove the rubble as quickly as possible so vegetation would not cover the newly exposed unwanted materials. After significant amounts of rubble were removed, we could revert to the original soil rebuilding plan and start a combination of cover-cropping, adding compost and other recommended soil amendments.

The main reasoning behind this approach is that the HUF management team believed it was best to remove as much rubble from each plot before beginning any additional soil remediation efforts. We didn't want to start rebuilding the soil in one phase and to have to come through later in a different phase and totally disrupt the soil again. It has been slow, physically demanding and has required considerable resources. After 4 years, we have enough land the has been 'cleared' of rubble and are working to establish a broader rotation with plots in different phases of the remediation process that can support the expanding programming and production goals of the farm.

SNAP BEAN HEAT STRESS, HEAT TOLERANT VARIETIES AND YIELD TRIALS

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Snap beans are sensitive to high night temperatures during flower development and pollination. High daytime temperatures are not as damaging to yield if plants are not drought stressed. Sixty-eight degrees Fahrenheit (68 °F) is considered the threshold temperature for damage to anthers and pollen. Flowers buds are susceptible to heat damage in the ten days before opening. High temperature damage interrupts pollination which leads to poor pod set, split sets, misshapen pods and reduced marketable yield.

Plantings of snap beans made in June and early July may be exposed to high night temperatures during the susceptible flower development period. Figure 1 shows the daily average minimum temperatures for Lancaster and State College, Pennsylvania for June, July, and August. These averages are based on 30 years of data (1991-2020). Average daily minimum temperatures are below the 68 °F threshold during the summer months. However, in certain years locations in Pennsylvania may experience extended periods with nighttime temperatures above this threshold. For example, in 2022 Atglen, PA experienced 33 nights with minimum temperatures that exceeded 68 °F in June through August 2022.

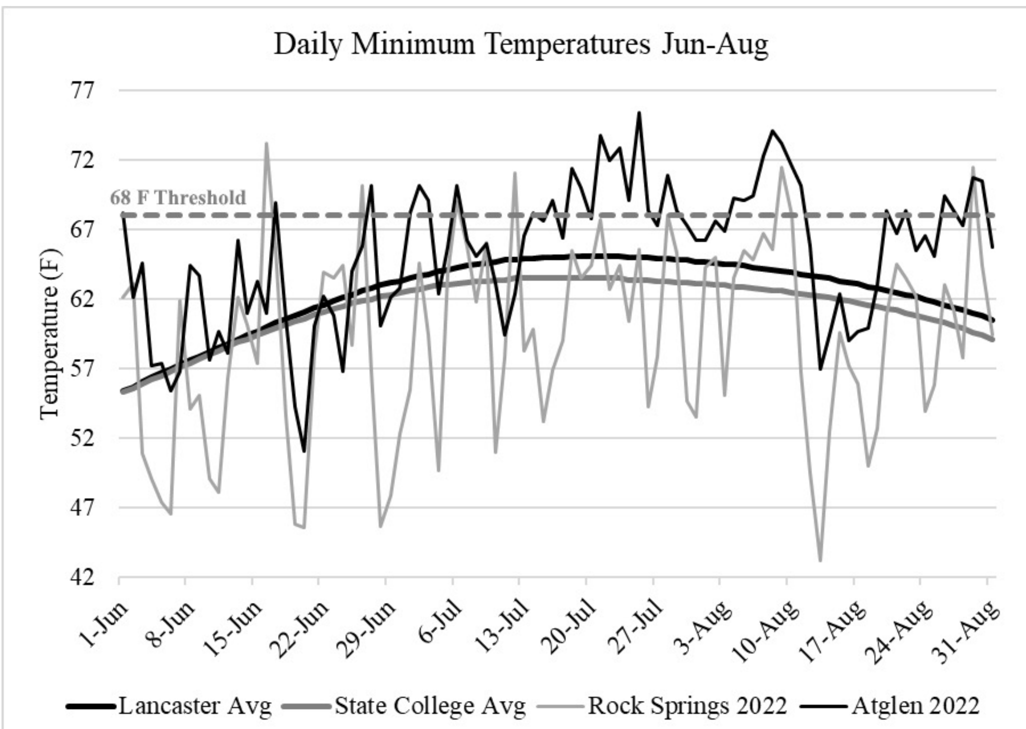

Figure 1. Average daily minimum temperatures for Lancaster and State College, Pennsylvania and 2022 daily minimum temperatures for Rock Springs and Atglen, Pennsylvania. Daily averages are of 30 years from 1991-2020; (data obtained from the National Centers for Environmental Information, https://www.ncei.noaa.gov/). Daily minimum temperatures for 2022 from NEWA, https://newa.cornell.edu.

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From 2017 to 2021 I conducted snap bean variety trials at the Carvel Research and Education Center in Georgetown, Delaware. At this location, snap beans planted in June and early July are reliably exposed to extended periods with high night temperatures. The purpose of these trials was to identify snap bean varieties that maintain yield and quality when night temperatures are higher than 68 °F.

Quality grading was an important part of evaluating varieties for heat stress tolerance. In heat stressed trials the heat tolerant varieties produced a higher percent marketable pods (Figure 2).

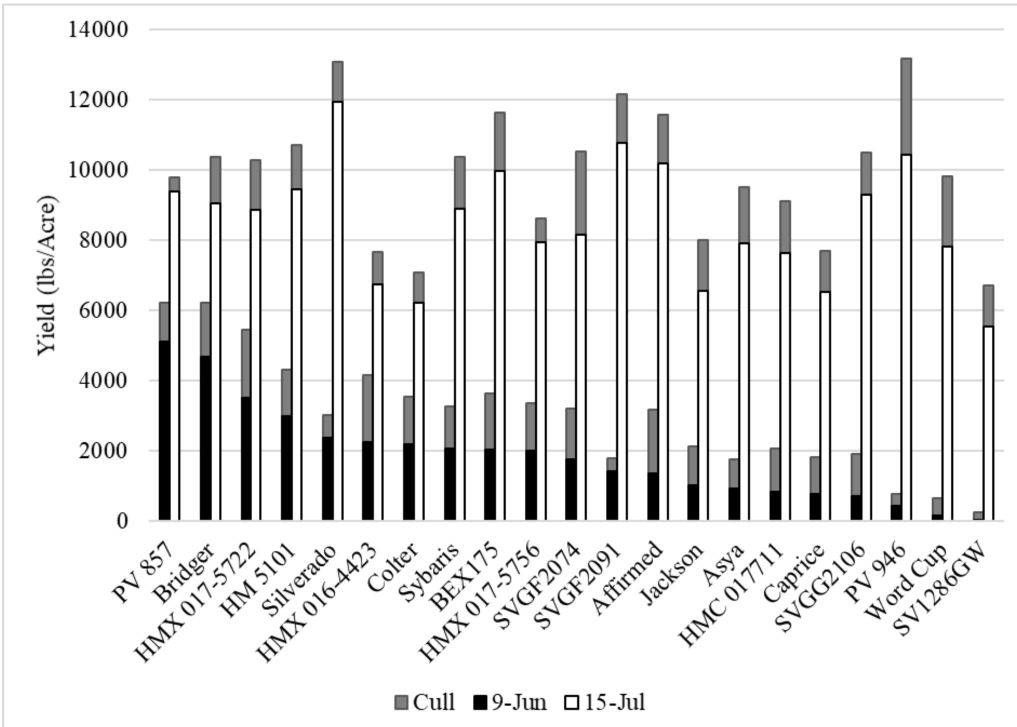

Figure 2. Yield results from the 2020 snap bean trials. The June 9 planting was heat stressed and the July 15 planting was not. White and black portions of bars denote the marketable proportion of total yield.

The round-podded varieties that produced the highest marketable yields under heat stress in multiple years of trials are ‘PV 857’ and ‘Bridger’. Two additional varieties of interest are ‘Jaguar’ and ‘Byrd’ (HMX 017-5722). Jaguar performed well in the 2021 heat stress trial but has only been trialed in Delaware for one year. Byrd has moderate heat tolerance based on 2020 and 2021 trials and was the highest yielding variety in a 2021 trial where many varieties succumbed to pythium root rot. Among the flat podded varieties tested in 2019 and 2021, ‘Usambara’ performed well under heat stress in both years and produced significantly higher yields than the other trialed varieties. ‘Tapia’ is another flat podded variety that had good yields in both years’ trials.

SNAP BEAN WEED MANAGEMENT UPDATE

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Pennsylvania, Delaware, Maryland, New Jersey, and New York combined grow over 46,000 acres of snap beans (NASS, 2017). Because of the crop's short stature and the comparatively short window between planting and harvest, season-long weed control is necessary to maximize snap bean production. Weeds that compete with the crop can also reduce harvest efficiency, harbor pests and pathogens, and interfere with the deposition of other pesticides. Many weeds emerge with the crop and must be rigorously managed to prevent direct and indirect impacts on crop yield.

Herbicide options are limited in snap beans with respect to 1) spectrums of control and 2) use patterns/rotation restrictions. For example, S-metolachlor (Dual Magnum) preemergence is rated excellent for the control of grasses, good to excellent for the control of pigweed, fair to good for the control of lambsquarters, and poor for the control of ragweed and velvetleaf. Halosulfuron (Sandea) applied preemergence is poor against grasses but good to excellent against many broadleaved species, except nightshades. Clomazone (Command) is poor against most broadleaves, but good for control of velvetleaf and grass. Fomesafen applied preemergence is poor against grasses, and good to excellent against most broadleaved species but has rotational restrictions that could impact use. The performance of soil-applied herbicides can be affected by a significant number of factors including rainfall, which is needed for activation. The longevity of pre-emergence herbicide efficacy can also be affected by rate, herbicide chemistry, soil type, organic matter, microbial composition, and other environmental factors like temperature, which can facilitate loss.

Postemergence applied herbicides are also valuable tools for preventing yield loss. Relatively few products are labeled for postemergence applications in snap beans, and each comes with constraints regarding use. Bentazon (Basagran) can control small lambsquarters, although other important species, like pigweeds, are not effectively managed. Fomesafen (Reflex), which is labelled for pigweed control, has limitations for number of applications that can be made over multiple years. Other products have significant rotation restrictions that can affect cropping decisions. All weeds should be treated with postemergence herbicides while they are small (typically < 2-3" in height or diameter). However, application timings must also factor in crop development to minimize injury potential and subsequent impacts on crop maturity. For example, bentazon, imazamox (Raptor), and formesafen applications must be made after the first trifoliate leaf is fully expanded. Research conducted in 2021 at Cornell, Penn State, and the University of Delaware showed that that early (cotyledon, unifoliate) applications of registered postemergence herbicides can result in significant crop injury and yield reductions, compared to applications made according to label recommendations (e.g. first fully expanded trifoliate leaf for the herbicides included in the trial). Injury symptoms can also persist across time, particularly if additional/external stressors (e.g. weather extremes) occur during the growing season. Crop plants that "get behind" early may not be able to "catch up". The addition of novel active ingredients would be valuable for suppressing unwanted vegetation. In 2022, a trial was conducted at Cornell, Penn State, and the University of Delaware to evaluate pyridate, a WSSA Group 6 herbicide (PSII-inhibitor), which is registered for use in chickpeas/garbanzo beans (Boydston et al. 2018. Weed Technol. 32:190-194) and has been/is being evaluated in lentils (Ahmadi et al. 2016. Weed Technol. 30:448-455) and peanuts (Edenfield et al. 2001. Weed Technol.15:419-423), and peas, suggesting that other members of the Fabaceae (bean family) may possess a level

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 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 is also interested in novel technology and is developing a program to evaluate precision sprayers, cultivators, and electric weeders.

of tolerance to the chemical. Preliminary results indicate that pyridate may not be an effective tool for use in snap beans; for example, in NY, observed injury was significant in some treated plots and marketable yields were reduced 15% to 35%. In 2023, snap bean research will be focused on the use of novel technology, including interrow mowers and camera-guided cultivation alone and in combination with registered herbicides.

Research into timing impacts on postemergence herbicide injury and potential use of pyridate in snap beans were funded by the Pennsylvania Vegetable Marketing and Research Program in cooperation with the Pennsylvania Vegetable Growers Association.

Research Funded by PA Growers

PVGA

PA PRODUCE

PA Veg. Growers Assn.

PA Veg. Mktg. & Research Prog.

RISKY OR NOT? USING AGRICULTURAL WATER ASSESSMENTS TO MANAGE FOOD SAFETY RISK

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Agricultural water is a cornerstone to fruit and vegetable production and its use must be managed effectively to achieve a high quality, safe crop for consumption. For those who have attended food safety training, you may already be aware that the Food Safety Modernization Act (FSMA) which was passed in 2011, included specific requirements for the safe production, harvest, and handling of fruits and vegetables (i.e., the Produce Safety Rule or PSR). The PSR includes basic good agricultural practices that growers and packers who are subject to the rule must follow which cover worker health and hygiene, management of domesticated animals and wildlife, soil amendment use, pre- and post-harvest water applications, and cleaning and sanitation practices. When FDA proposed the PSR in 2013, it quickly became clear that FDA had missed the mark regarding agricultural water requirements (also called Subpart E), with the industry citing challenges related to the very prescriptive, testing-oriented approach FDA took for agricultural water safety. In 2017, FDA announced the extension of compliance dates for Subpart E, then used enforcement discretion until revised requirements could be put forth that were more workable for the produce industry and more meaningful from a public health standpoint. That proposed revision published in December 2021 and we're still awaiting a final version to be released.

The good news is that the proposed revision takes a more holistic, systems approach which provides flexibility for each grower to make risk-based decisions appropriate to their operation. Enter the *agricultural water assessment (AgWA)*. The AgWA moves away from the one-size-fits-all standard based on test results as originally proposed through the development of what FDA called the Microbial Water Quality Profile (MWQP). The holistic approach is preferred by many in the industry, however, will require most growers to develop a new skill set in order to conduct an effective AgWA.

So, what can you do in the meantime?

- Start to familiarize yourself with the terms **hazard** and **risk**. These are terms you are likely to see in the final rule and are critical to understand to conduct an AgWA effectively.
    - o A hazard is anything with the potential to cause harm.
    - o A risk is generally explained as the combination of the likelihood of a hazard occurring and the severity of the hazard, if it does occur.
    - o Example: The presence of a hazard alone does not equate with a risk. Just because there is a gasoline spill, does not mean it is inherently risky…that is unless a flame is placed near it.

Gretchen is the Director of Food Safety and Quality at the International Fresh Produce Association (IFPA) which was created from the transformation of the legacy associations Produce Marketing Association (PMA) and United Fresh Produce Association (United Fresh). She supports IFPA members and industry stakeholders by providing technical support, educational opportunities, and science-based information on all aspects of produce safety and quality from farm to fork.
Gretchen's background in food science and food safety enables her to assist a wide variety of food producers as they navigate complex regulatory requirements and market demands. Her background in education and extension at Cornell University's Produce Safety Alliance allows her to guide growers and packers toward practical and achievable food safety outcomes, foster long-term business viability, and work towards achieving public health goals.
Gretchen earned her M.S. in Interdisciplinary Studies in Food Science and Safety at Colorado State University and her B.S. in Food Science at The Pennsylvania State University. She is the current Chair of the International Association of Food Protection's (IAFP) Fruit and Vegetable Safety and Quality Professional Development Group and a Provisional Subject Matter Expert for the Center for Produce Safety (CPS) Technical Committee. Gretchen resides in State College, PA where she explores the many trails and state forests on foot, skis, and by bike with her husband and 2-year-old son, Lander.

- Begin conducting a **hazard assessment** – what can impact your water sources seasonally, daily, or when environmental factors come into play (e.g., a heavy rain event that might be likely to cause run-off into your irrigation pond)?
    - o Consider your water source (e.g., pond, river, canal, well), what crops water is being applied to (e.g., row crop vs. tree), how water is being applied (e.g., drip, overhead, flood), the water delivery system (e.g., pipes, pumps, water conveyances), and adjacent land uses.
    - o Consider putting together a team of individuals who can look at agricultural water practices and the growing environment but may see the situation through a different lens (i.e., expand your team beyond just food safety, include field workers, foreman, etc.). This will help you capture the potential variability and likelihood of a hazard occurring – as well as what might be done to prevent it from becoming a risk.
- Once hazards have been identified, you can **rank them to support your decision-making** on how best to use the farm's resources.
    - o Which hazard is most likely to occur?
    - o Which hazard would result in a more severe consequence?
    - o Which hazards are "low-hanging fruit" to address to minimize a potential risk?
- **Document the process and outcomes of your AgWA** and support it with additional data. Though the proposed rule has removed the prescriptive water testing requirements, there may be instances where supporting your decision-making process with additional information, such as through test results, may be helpful. Water testing should not be a standalone activity to reduce risk.
- **Use your resources wisely and stay up to date with the regulation.** Though we do not know what details will emerge from the final rule nor the timeline for compliance, it is critical to start taking these steps now. Several resources are listed below as tools to help you conduct an agricultural water assessment and where you can get the latest information on Subpart E, when it is finalized.
    - o Assessing Risk of Pre-Harvest Agricultural Water: https://www.freshproduce.com/siteassets/files/food-safety/assessing-risk-of-pre-harvest-agricultural-water-1.pdf
    - o Example documentation for a water system risk assessment: https://www.freshproduce.com/siteassets/files/reports/food-safety/example-documentation-for-ag-water-risk-assessment.pdf
    - o Your local Extension professional or the IFPA food safety team: https://www.freshproduce.com/resources/food-safety/food-safety-resources-and-services/
    - o Produce Safety Alliance: Sign up for the newsletter to receive updates on the final rule and future educational opportunities/resources. https://cals.cornell.edu/produce-safety-alliance

FEASIBILITY OF MESOTUNNELS FOR MUSKMELON PRODUCTION

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Cornell AgriTech

The management of a complex of pests and diseases affecting cucurbits are acutely challenging for organic farmers, and the priority insect-vectored bacterial disease for muskmelon is:

Bacterial Wilt (BW) is caused by the bacterium, *Erwinia tracheiphila*, and spread by striped (*Acalymma vittatum*) and spotted cucumber beetles (*Diabrotica undecimpunctat*a). Symptoms of BW include the sudden onset of wilting and drying of foliage (**Fig. 1**). Cucumber, muskmelon, and honeydew are highly susceptible to BW. Squash and pumpkin are moderately susceptible to BW, and watermelon is immune.

Fig. 1. Bacterial wilt symptoms in muskmelon.

Row covers have potential to manage major pests and insect-vectored pathogens. Row covers are structures deployed over the crop that exclude pests and moderate weather extremes (e.g., hail). Row covers differ in height and hence the terms, low and high tunnels. Mesotunnels are a medium-size tunnel (36-42 in. high; **Fig. 2**). A breathable and tough nylon-mesh, breathable fabric (e.g., ProtekNet or ExcludeNet) is placed over hoop structures above the plant canopy and the fabric is secured to the ground. Pesticides can be applied through the fabric without the need for lifting and breaking the exclusion barrier. Mesotunnels have the potential to offer full-season crop protection but naturally occurring pollinators are also excluded. The objective of this study was to evaluate selected strategies to optimize pollination and performance (plant health and fruit yield) of muskmelon in an organic mesotunnel.

Treatments and experimental design. The experiment was conducted at the Gates West Certified Organic Farm of Cornell AgriTech, Geneva, NY in 2022. Muskmelon seedlings (cv. Athena) were transplanted by hand on 28 June with 24 inch spacing. After transplanting, mesotunnels were established by placing the front end of the hoops every 7-feet in a zig-zag pattern. ExcludeNet (Tek-Knit Industries, Mount Royal, Quebec) of dimensions 160 feet x 26 feet was then stretched across plots (150 feet long x 3 rows wide). The ExcludeNet was secured by sandbags at 5-10 feet intervals. The experimental design was a completely randomized block with four replications of each treatment over

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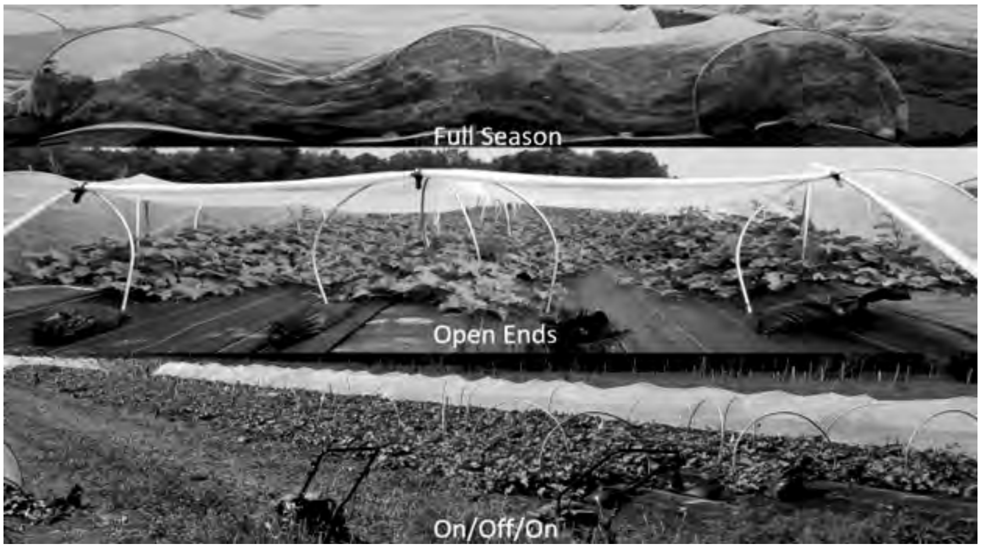
the three-week flowering period **(Fig. 2)**.

- On/off/on involving complete removal of the netting over flowering followed by replacement;
- Open ends only during flowering; and
- Closed tunnels with one bumblebee (Bombus impatiens) commercial hive (Koppert).

Fig. 2. Mesotunnels for muskmelon production demonstrating the three treatments evaluated in the field trial at Geneva, NY, in 2022.



Regular (~ weekly) assessments of disease incidence and pest populations were made throughout the season. Fruit was manually collected from the center rows on 31 August and 6 September, weighed and graded. The effect of treatment was analyzed using a one-way analysis of variance.

Results. BW epidemic progress was significantly affected by treatment and significantly lower in the on/off/on treatment than closed and open ends tunnels which were not significantly different between each other. Cucumber beetle populations over the season were significantly reduced in closed and open ends tunnels but not significantly different between each other, compared to the on/off/on treatment **(Table 1)**.

Treatment had a significant effect on the number of marketable fruit and marketable fruit weight **(Table 1)**. Tunnels with the on/off/on treatment produced 77.9% and 74.5% more fruit than those with open ends or that were closed, respectively. The percent of marketable fruit was also significantly higher in tunnels with the on/off/on treatment than in those with open ends or closed which were not significantly different between each other. Marketable fruit weight was significantly higher (636 to 650%) in the on/off/on treatment than the open ends and closed tunnel which were not significantly different between each other (Table 1). Treatment had no significant effect on the number and weight of unmarketable fruit.

Table 1. Effect of treatment on bacterial wilt and cucumber beetle populations, and muskmelon yield.

Variables	On/Off/On	Open Ends	Closed	LSD	P =
Bacterial wilt epidemic progress	5 b	113 a	99 a	42	0.046
Spotted + striped cucumber beetles	82.8 a	24.5 b	3.5 b	47.3	0.016
Marketable fruit (%)	61.9 a	13.2 b	12.0 b	16.3	<0.001
Nonmarketable fruit (%)	38.1 b	86.8 a	88.0 a	16.3	<0.001
Total number of fruit	274 a	154 b	157 b	65.4	0.006
Number of marketable fruit	167.8 a	20.0 b	19.8 b	28.6	<0.001
Total marketable fruit weight (lb)	862 a	115 b	117 b	155.6	<0.001
Number of unmarketable fruit	107	134	137	-	0.462 (ns)
Total unmarketable fruit weight (lb)	426	448	594	-	0.247 (ns)

Conclusions. BW epidemic progress was significantly higher in the open ends tunnels compared to closed and on/off/on treatments. However, cucumber beetle populations were significantly higher in the on/off/on treatment compared to the open ends and closed tunnels, which were not significantly different from each other. The lack of benefits in marketable fruit number and weight associated with the closed tunnel system dissuades the commercial purchase of hives for optimal muskmelon yield. When taken together with considerations for BW, the use of the on/off/on treatment resulted in less disease incidence than in open end tunnels. The substantial increases in marketable fruit number and weight associated with the on/off/on treatment compared to the open ends suggests this treatment is likely the most beneficial for protected, organic production of muskmelon in New York. Additional economic analyses will provide the basis for grower recommendations surrounding the facilitation of pollination.

Acknowledgments. We are grateful for funding through the USDA-NIFA Organic Research and Extension Initiative led by Iowa State University (project 2019-51300-30248).

Other Resources: Please visit our project's website and follow us on Twitter to stay up to date on the latest mesotunnel news.

- The Current Cucurbit Project: https://www.cucurbit.plantpath.iastate.edu/
- Twitter: @TCucurbit;
- YouTube: The Current Cucurbit
- Join our mailing list: cucurbit-news@iastate.edu

UPDATE ON CONTROL OPTIONS FOR HARD-TO-MANAGE INSECT PESTS OF VEGETABLES

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Vegetable crops are attacked by a diverse suite of insect pests that can impact marketable yield through feeding injury or their sheer presence on the produce. This talk will summarize several insecticide efficacy experiments conducted in 2022 in Virginia on some of the more problematic pests of vegetables in the mid-Atlantic U.S.

Flea beetles and harlequin bugs.

Diamides and spinosyns are two of the most popular and efficacious insecticide groups to control lepidopteran pests. They are particularly important on brassica crops, which have so many lepidopteran or "worm" pests. The effectiveness of these insecticides against non-lepidopteran pests is less understood. In this trial, we evaluated the effectiveness of the diamide Harvanta (cyclaniliprole) and the spinosyn Radiant (spinetoram) on our primary pests, flea beetles and harlequin bugs, in cabbage. We also tested the Group 4D butenolide insecticide Sivanto Prime applied as a soil drench. The experiment was conducted in Whitethorne, VA on 'Blue Lagoon' cabbage transplanted on 3 June 2022. Treatments were applied twice (17 June for flea beetles and 15 July for harlequin bugs). Flea beetles were mostly striped flea beetle *Phyllotreta striolata*. All three insecticides, Harvanta, Radiant, and Sivanto significantly reduced flea beetle numbers on plants (Table 1A) with the drench treatment of Sivanto providing excellent residual control up to 7 days post treatment. Sivanto Prime showed excellent control of Harlequin bugs, whereas Radiant and Harvanta were not effective (Table 1B).

Table 1. Insecticide efficacy on cabbage in Whitethorne, VA.

A. Flea beetles			# of flea beetles per 5 plants			
Treatment	Rate/Acre	Application Method	20 Jun (3 DAT1)	24 Jun (7 DAT1)	19 July DAT2)	21 July (6 DAT2)
Untreated Check	-	-	18 ± 10 a	30 ± 12 a	38 ± 13 a	50 ± 14 a
Harvanta 50SL	5.5 fl. oz	Foliar	1± 2 b	12 ± 6 ab	2 ± 3 b	3 ± 3 c
Radiant	5.0 fl. oz	Foliar	2 ± 1 b	21 ± 10 ab	4 ± 3 b	25 ± 6 b
Sivanto Prime 200SL	21.0 fl. oz	Soil drench	3 ± 2 b	5 ± 2 b	3 ± 3 b	6 ± 6 c
P-value from Anova			<0.001	<0.001	<0.001	<0.001

B. Harlequin bugs			#Harlequin bug nymphs per 5 plants		
Treatment	Rate/Acre	Application Method	19 Jul (4 DAT20	21 Jul (6 DAT2)	25 Jul (10 DAT2)
Untreated Check	-	-	6.0 ± 5.9 a	10.5 ± 7.0 a	20.8 ± 9.9 a
Harvanta 50SL	5.5 fl. oz	Foliar	6.25 ± 3.9 a	15.8 ± 14.0 a	14.8 ± 10.1 a
Radiant	5.0 fl. oz	Foliar	6.3 ± 4.2 a	8.8 ± 10.4 a	14.8 ± 18.3 a
Sivanto Prime 200SL	21.0 fl. oz	Soil drench	0.3 ± 0.5 b	0.5 ± 0.6 b	1.0 ± 0.8 b
P-value from Anova			0.001	0.01	0.05

Means within columns followed by a letter in common are not significantly different (P>0.05).

Stink bugs

Stink bug problems are getting worse on fruiting vegetables and beans in the Mid-Atlantic U.S. In the past decade, the invasive brown marmorated stink bug has become established as a major pest species adding to the native complex of stink bugs. More recently, the southern green stink bug, a pest historically located the Deep South, has expanded its range and is now well established in eastern Virginia and contributing significantly to stink bug pest problems. In this trial conducted on 'Better Boy' round tomatoes transplanted on 18 May in Painter, VA, we evaluated four insecticides: the pyrethroid bifenthrin, the neonicotinoid Venom (dinotefuran), the combo product Argyle (mix of the neonicotinoid acetamiprid + bifenthrin – not yet labeled on vegetables), and the carbamate Lannate LV (methomyl). Treatments were applied three times (13, 20 and 27 July). Southern green stink bug was the predominant pest and contributed to an average of 20% and 30.8% damage to harvested fruit in the untreated control on 27 July and 3 Aug, respectively. Venom provided the best control among the treatments while Lannate did not reduce stink bug damage on either harvest (Table 2).

Table 2. Insecticide efficacy on stink bugs on tomato in Painter, VA.

		% of fruit with stink bug damage	
Treatment	**Rate/Acre**	**27-Jul (7 DAT2)**	**3-Aug (7 DAT3)**
Untreated Check	-	20.0 ab	30.8 a
Bifenthrin 2EC	6.4 fl. oz	11.7 b	19.2 abc
Argyle OD	9 fl. oz	12.5 b	13.3 bc
Venom 70SG	4 oz	10.8 b	6.7 c
Lannate LV	24 fl. oz	26.7 a	25.8 ab
P-value from Anova		0.0079	0.032

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).

Mexican bean beetle

Mexican bean beetle can be a major pest of snap beans. Our trial conducted in Whitethorne, VA on 'Caprice' snap bean planted 19 June showed that many of the newer insecticides such as the diamides Vantacor, Elevest, and Harvanta along with Torac (tolfenpyrad, a group 21 METI insecticide that disrupts cellular respiration) provided effective control of this pest (Table 3). Additionally, Spear T (a novel peptide insecticide which is not labeled for MBB) provided suppression (Table 3). Treatments were applied on 3 and 12 Aug.

Table 3. Insecticide efficacy on Mexican bean beetle in Whitethorne, VA.

		# MBB per 1 min visual inspection			
		8 Aug (5 DAT1)		**15 Aug (3 DAT2)**	
Treatment*	**Rate/Acre**	**Adult**	**Larvae**	**Adult**	**Larvae**
Untreated Check	-	2 ± 0 a	7 ± 4	1 ± 0	10 ± 2 a
Vantacor	1.66 fl. oz	1 ± 0 b	1 ± 1	1 ± 1	0 ± 0 c
Spear T	384 fl. oz	0 ± 0 c	5 ± 2	0 ± 0	5 ± 3 b
Torac	14 fl. oz	0 ± 0 c	1 ± 1	0 ± 0	0 ± 0 c
Elevest	5.6 fl. oz	0 ± 0 c	0 ± 0	0 ± 0	0 ± 0 c
Harvanta 50SL	10.9 fl. oz	0 ± 0 c	0 ± 0	0 ± 0	0 ± 0 c
P-value from Anova		<0.001	ns	ns	<0.001

*All treatments had Latron LI-700 NIS added at 0.5% v:v.

Corn earworm

In the mid-Atlantic U.S., one of the most important lepidopteran pests of vegetables is corn earworm (CEW) *Helicoverpa zea*, which drives the majority of insecticide applications on sweet corn, and attacks other crops including tomatoes and beans. Resistance to Bt Cry proteins as well as pyrethroids in CEW populations has made pest management difficult and costly. Rotating insecticide MOAs is a sound strategy for CEW control. In Whitethorne, VA we evaluated several different insecticide rotations beginning at tasseling and spraying every 2-3 days (total of 7 applications) on 'American Dream' sweet corn, planted 7 July. Rotations that included Lannate LV, Bifenture, Lambda-cyhalothrin, and Rimon (trts 2 and 3) or any of the diamides such as Coragen, Vantacor, Elevest or GPI220 (=chlorantraniliprole) rotated with bifenthrin then Lannate (trts 6,7,8,9) provided excellent control of CEW based on % clean ears, % total damaged ears, and numbers of CEW larvae found per 25 ears (Table 4). The biopesticide product Heligen, which includes baculovirus particles specific to CEW did not perform well even in a rotation with Coragen then bifenthrin (trt 4). However, the addition of Optimol (petroleum + molasses), which acts as a feeding stimulant for CEW, significantly improved the efficacy of Heligen (see trt 5 vs. 4).

Table 4. Insecticide efficacy on corn earworm on sweet corn in Whitethorne, VA.
rotated with Coragen (d,e)

Treatment (spray interval)	Rate/Acre	% clean ears	% total worm damaged ears	# CEW larvae per 25 ears
1. Untreated Check		30 ± 11 b	71 ± 11 a	26 ± 7.6 a
2. Lannate LV (at tassel) (a) fb Bifenture 2EC (b) plus Lambda-cy (b,c) fb Lannate LV (c,d) plus Rimon (d) fb Rimon (e,f) fb Lannate LV (g)	24.0 fl. oz 4.8 fl. oz 3.5 fl. oz 24.0 fl. oz 12.0 fl. oz 12.0 fl. oz 24.0 fl. oz	100 ± 0 a	0 ± 0 b	0 ± 0 c
3. Lannate LV (at tassel) (a) fb Rimon (b,c) fb Lannate LV (d) plus Rimon (d) fb Bifenture 2EC (e,f) plus Lambda-cy (e,f) fb Lannate LV (g)	24.0 fl. oz 12.0 fl. oz 24.0 fl. oz 12.0 fl. oz 4.8 fl. oz 3.5 fl. oz 24.0 fl. oz	98 ± 1 a	2 ± 1 b	1 ± 0.3 bc
4. Heligen (a,b,c) rotated with Coragen (d,e) rotated with Bifenthrin 2EC (f,g)	2.4 fl. oz 5.0 fl. oz 4.8 fl. oz	46 ± 8 b	54 ± 8 a	18 ± 3 a
5. Heligen (a,b,c) plus Optimol (a,b,c) rotated with Coragen (d,e) rotated with Bifenthrin 2EC (f,g)	2.4 fl. oz 27.0 fl. oz 5.0 fl. oz 4.8 fl. oz	88 ± 10 a	12 ± 9 b	5 ± 3 b
6. GPI220 (=chlorantraniliprole) (a,b) fb Bifenthrin 2E (c,e,g) fb Lannate LV (d,f)	2.5 fl. oz 4.8 fl. oz 24.0 fl. oz	97 ± 2 a	3 ± 2 b	0 ± 0.3 c
7. Elevest (a,b) fb Bifenthrin 2E (c,e,g) fb Lannate LV (d,f)	9.6 fl. oz 4.8 fl. oz 24.0 fl. oz	99 ± 1 a	1 ± 1 b	0 ± 0 c

Treatment (spray interval)	Rate/Acre	% clean ears	% total worm damaged ears	# CEW larvae per 25 ears
8. Vantacor (a,b) fb Bifenthrin 2E (c,e,g) fb Lannate LV (d,f)	2.5 fl. oz 4.8 fl. oz 24.0 fl. oz	97 ± 2 a	3 ± 2 b	0 ± 0.3 c
9. Coragen (a,b) fb Bifenthrin 2E (c,e,g) fb Lannate LV (d,f)	5.0 fl. oz 4.8 fl. oz 24.0 fl. oz	93 ± 5 a	7 ± 5 b	1 ± 1 bc
P-value from Anova		<0.001	<0.001	0.001

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).

Organic sweet corn

Organic sweet corn growers have very few insecticide options aside from the spinosyn Entrust and none that meet the control levels produced by many of the synthetic insecticides that were tested in Table 5. Products containing Bt kurstaki (such as Dipel or Javelin) or Bt aizawai (such as Xentari or Agree) are good organic biological insecticides for many leaf-feeding lepidopteran pests, but unfortunately have not performed well at controlling CEW due to resistance. In Whitethorne, VA we evaluated several different organic insecticide options and rotations with Entrust for control of CEW. Sprays were initiated at tasseling and repeated every 2-3 days (total of 7 applications) on 'American Dream' sweet corn, planted 7 July.

The best control of CEW was obtained with either Entrust SC for all 7 applications (trt 2), which exceeds the maximum amount per season, or Entrust rotated with Azera (azadirachtins + pyrethrins) trt 3 (Table 5). Effective control of CEW was not achieved with Heligen alone, or in combination with Optimol feeding stimulant, or either treatment in rotation with Entrust (Table 5).

Table 5. Organic insecticide efficacy on corn earworm on sweet corn in Whitethorne, VA.

Treatment	Rate/Acre	% clean ears	% total worm damaged ears	# CEW larvae per 25 ears
1. Untreated Check	-	28 ± 14 c	72 ± 1 a	31 ± 8
2. Entrust SC (a-g)	4.0 fl. oz	91 ± 6 a	9 ± 1 c	1 ± 1
3. Entrust SC* (high limit 4 apps) (a-d) fb Azera (e-g)	6.0 fl. oz 56.0 fl. oz	98 ± 1 a	2 ± 1 c	1 ± 1
4. Heligen (a-c) rotated with Entrust SC (d-f)	2.4 fl. oz 6.0 fl. oz	58 ± 10 bc	42 ± 1 ab	11 ± 3
5. Heligen + Optimol (a-c) rotated with Entrust SC (d-f)	2.4 + 27.0 fl. oz 6.0 fl. oz	57 ± 12 bc	43 ± 1 ab	13 ± 5
6. Heligen (a-g)	2.4 fl. oz	56 ± 18 b	44 ± 1 b	13 ± 4
7. Heligen + Optimal (a-g)	2.4 + 27.0 fl. oz	43 ± 19 bc	57 ± 1 ab	20.5 ± 4
8. Heligen + Azera (a-g)	2.4 + 56.0 fl. oz	31 ± 15 bc	69 ± 1 ab	26 ± 4
P-value from Anova		<0.001	<0.001	<0.001

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).

LESSONS LEARNED OVER A CAREER ABOUT VEGETABLE DISEASES, MANAGEMENT AND FUNGICIDE RESISTANCE

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'Change', 'unexpected', 'rewarding', and 'satisfying' are the main words that come to mind when I think about my career as a vegetable pathologist with a research/extension appointment. My entire career has been with Cornell University located on Long Island in one of the most important agricultural counties in New York based on value of production. I started in July 1988 right after obtaining my PhD from Penn State. Over the 34 years there have been a lot of changes in pathogens, diseases, and their management. Observed changes in pathogens have mostly been the result of evolution. There has been much more change than I would have expected over the relatively short time period of a career when I started. Many of the lessons learned pertain to these changes and can be summarized as "expect the unexpected", which is expected to continue! The need for monitoring occurrence of resistance in the cucurbit powdery mildew pathogen and detecting development of resistance to additional fungicide chemistry – needed to be able to develop sound fungicide recommendations – has continued throughout my career. This research was initiated because pumpkin growers on Long Island were experiencing control failure with the targeted fungicide being used when I started. My feeling that my research/extension program has been worthwhile and successful comes from the statements of gratitude I have received from growers, extension specialists and other stakeholders when I've diagnosed a disease, answered a question, given a presentation they appreciated, etc. It has also been rewarding and satisfying to receive acknowledgement of my accomplishments from my scientist colleagues, but not quite as rewarding as when I hear from stakeholders.

Several changes in pathogens during my career lead to change in disease occurrence and a need to promptly change priorities and focus on getting information to growers. Descriptions of the most important are below. For a pathologist, these changes have been scientifically fascinating. Hard not to be amazed by pathogens' ability to evolve while focused on trying to help growers.

Cucurbit downy mildew. In 2004, this disease that had been occurring sporadically and thus was of minor importance, started occurring regularly throughout the eastern U.S. and potentially causing major impact on yield and fruit quality when not managed. Before 2004, this disease was being very effectively managed by genetic resistance that had been bred into cucumber and by two targeted fungicides, Ridomil and Quadris. Re-emergence of downy mildew was due to a change in the pathogen such that it was no longer able to be effectively managed by the resistant varieties or these fungicides. Downy mildew has remained an important disease of cucurbit crops. Today it is effectively managed with new resistant varieties, new targeted fungicides, and a monitoring/forecasting program to guide when fungicide applications are warranted. The pathogen has continued to change, developing resistance to additional fungicides. And it should be expected to continue to change, potentially developing resistance to more fungicides and over-coming genetic resistance. An additional concern is for the two mating types to start to occur

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together routinely – they now occur dominantly on different cucurbit types – especially in northern states, because this will enable the pathogen to produce oospores which can survive over winter, thereby enabling earlier onset of downy mildew in addition to more opportunity for change in the pathogen because oospores are produced through sexual reproduction.

Phytophthora blight. This was a new disease on Long Island during the start of my career. In 2008 *Phytophthora capsici* was found infecting snap beans in New York, which was five years after blight was first reported on this new host in Michigan. This was an extremely unexpected host range expansion for a pathogen because beans are not related to the pathogen's other hosts (cucurbits, pepper, eggplant, tomato), and this host range is somewhat narrow. Fortunately, Phytophthora blight has rarely re-occurred on beans.

Basil downy mildew. This disease has occurred routinely and remained the most important constraint to basil production in the northeast since 2008 when it was first observed there. It was first detected in the U.S. in fall 2007 in Florida and before that there were several first reports elsewhere in the world during the 2000s. Prior to that the only published report was in Uganda in 1933. It remains unknown what caused the enormous change in occurrence of this disease, but change in the pathogen could have occurred. There were no management practices in the U.S. in 2007. Because basil is the most common herb grown by diversified vegetable growers, some vegetable pathologists with extension appointments, including myself, expanded their programs to address this grower need. Effort included seeking funding through the IR-4 program to conduct evaluations of fungicides (efficacy and crop safety) while their staff did the residue studies and other work to obtain registration. Disease occurrence was studied. And we pathologists worked with herb breeders to develop resistant varieties. The pathogen has demonstrated ability to evolve becoming resistance to fungicides and able to overcome host plant resistance. Changes are expected to continue thus there will continue to be a need for research.

Late blight of tomato and potato. The pandemic of 2009 is a good example of the very unexpected occurring and of extension pathologists throughout a region coming together to share observations and develop a response plan. Widespread occurrences of late blight during June was completely unexpected by growers and pathologists because late blight had been occurring sporadically in the U.S., often only in major potato production areas, and in the northeast it had not been seen so early in the growing season. The fact that the source was infected tomato seedlings sold at garden centers throughout the region was unprecedent and thus unexpected. This was the first time home gardens were an important source of a pathogen for growers. The causal pathogen turned out to be a new genotype (US-22) that was more virulent on tomato then the genotype that had been dominant in the U.S. and mostly affected potato. The late blight pathogen exists in the U.S. as clonal populations with only a few genotypes present each year. Late blight continued to be very important for several years after 2009, especially in the northeast, with three new genotypes arising. Then the disease returned to being generally uncommon. There remains concern about a major change occurring in the pathogen such that its two mating types (pathogen equivalent of gender) start to exist together, because then the pathogen will be able to produce oospores enabling it to survive overwinter in soil in the absence of living host plant tissue (in infected potato tubers is how the pathogen currently survives). This change has already occurred in parts of Europe where consequently late blight now occurs routinely and new genotypes appear more commonly due to sexual reproduction.

Potato blackleg caused Dickeya. This destructive, seed-borne pathogen caused extensive losses starting possibly as early as 2013 on Long Island. It is one of several factors that led to substantial decline in potato production in the area. The pathogen is now uncommon.

Some diseases that were observed rarely during my career include Stemphylium leaf spot of spinach, Septoria leaf spot of lettuce, garlic rust, Cercosporoid leaf blight of dill, downy mildew of arugula, and powdery mildews on field grown lettuce, pepper, and carrots (different pathogens). Stewart's wilt of corn, white rust of spinach, and turnip mosaic virus are diseases I detected on Long Island early in my career that have not been seen since. Downy mildew of spinach re-emerged recently primarily as a disease in winter tunnels. It is caused by another pathogen that has proven adept at change, with new races continually appearing that overcome resistance varieties, the main management practice. Stemphylium (gray) leaf spot of tomato is a new disease occurring mainly in high tunnels where temperatures are high enough for it.

Novel management practices. During my career I have evaluated a diversity of practices including soil solarization, reduced tillage, and mustard biofumigation for Phytophthora blight.

Fungicide resistance. Pathogens evolving ability to be unaffected by fungicides is the most common change in pathogens occurring during my career. The main change in the pathogen is to the site where the fungicide binds. There have been several lessons learned while studying fungicide resistance and its management, which are important for improving management strategies. These lessons include now recognizing that predicting potential risk of resistance developing for a new fungicide can be difficult, as can predicting pathogen propensity. When Quadris, the first QoI (FRAC 11) fungicide was registered, the manufacturer thought resistance risk was not high, thus there was not a need to implement a resistance management program right away. Additionally, the cucurbit powdery mildew pathogen was anticipated to be the first to develop resistance to this new chemistry, but the gummy stem blight pathogen was first. An education lesson for growers is that the goal of fungicide resistance management is delaying development of resistance, not managing resistant isolates after they have appeared. Surprisingly, the cucurbit powdery mildew pathogen has not continued to develop resistance to the DMI (FRAC 3) fungicides since 1990 when control failure to the first DMI registered in the U.S. for this use (Bayleton; active ingredient triadimefon) was shown to be associated with occurrence of resistance. Some DMIs, Proline in particular, have continued to exhibit excellent control. Having a good resistance management program cannot prevent resistance development. Resistance to Torino (FRAC U6) was detected just five years after its registration for this use although its use was restricted more than other fungicides with just two applications permitted to a crop, and there were other effective fungicides to apply in alternation to manage resistance (DMIs and Quintec, plus Vivando two years later). Resistance to Pristine was detected six years after its registration and to Quintec eight years afterwards. The resistance management program for these three chemistries may have had an impact considering resistance to Quadris developed in just three years. Another lesson is that resistant isolates typically are not less fit and thus can occur in crops not treated with the fungicide. Frequency of resistance can change substantial in response to fungicide use in a crop during a growing season. When a fungicide applied to a commercial crop is ineffective because of resistance, it may not have an evident impact on control when the other fungicides used in the rotation program are effective, necessitating testing for resistance to detect. Ability of pathogens to develop resistance to chemically different fungicides (up to five FRAC groups for cucurbit powdery mildew) was not expected and makes fungicide resistance management more challenging.

EVALUATION OF GRAFTED WATERMELON FOR FUSARIUM WILT MANAGEMENT

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Introduction: Fusarium Wilt, caused by the soil borne pathogen Fusarium oxysporum f. sp. niveum is becoming more problematic in seedless watermelon production in Southern Maryland. Unfortunately, there are few effective management options for this soil borne disease. New races of fusarium wilt are now present in the area that can overcome traditional cultivar resistance. Effective fungicides are limited and do not provide season long control at labeled rates. In many cases, once a field is infested with fusarium wilt, watermelon production is no longer a viable option. A technique that has been effective in other areas is grafting of susceptible cultivars onto fusarium resistant rootstocks of interspecific hybrid squash or citron species. Watermelon grafting is more difficult than tomato grafting and is normally done by outside companies who specialize in the technique. During the 2020 and 2021 growing season, a field research and demonstration trial was conducted at several farms with a history of fusarium wilt to evaluate the efficacy of grafting for fusarium management. A second study was undertaken in the 2022 growing season to evaluate the optimum plant population for grafted watermelon.

Fusarium Wilt Management 2020-2021

Methods: Grafted plants of the seeded cultivar Jubilee were used as the pollinizer cultivar and grafted plants of the cultivar Fascination were used as the seedless cultivar. Tri-Hishtil (25 School House Rd, Mills River, NC 28759 (P) 828-620-5020), a commercial firm in North Carolina specializing in grafting donated the plants for the trial. Both Jubilee and Fascination scion were grafted toeither an interspecific squash rootstock or a "Carolina Strongback" Citron rootstock. Non-grafted Jubilee and Fascination plants were planted at four or five replications (locations) throughout the field and flagged for later comparison. Each farm used conventional management practices, including black plastic mulch, drip irrigation, and fertigation. Each site used different in-row and between row spacing. A total of seven sites with a history of fusarium wilt participated in the trial.

The 2020 season was not favorable for main season watermelon production. Heavy rains began in July and continued with the remnants of Hurricane Isaias bringing up to 12 inches of rain over the region in early August. Rains continued through the harvest period. Rain totals for the season were recorded at 80.26 inches, a record for the year and far beyond the normal of 45 inches. As a result of the extremely wet season, Phytophthora fruit and root rot was wide spread, particularly on two of the farms with heavier Beltsville silt loam soil. The third location was located on sandy loam soil and did not exhibit heavy phytophthora losses through most of the field. The 2021 season was favorable for main season watermelon production. Phytophthora fruit and root rot was present on one location toward the end of the season. Yield data presented focuses upon the farm with minimum phytophthora pressure.

Grafted and non-grafted plants were examined throughout the season. Data on root viability, root knot nematode presence and vine condition were recorded. At harvest, 3 plants of each cultivar/rootstock combination from each replication were evaluated for viable root count, vine condition, root knot nematode presence and other comments. Yield data from plants grafted to Citron and plants grafted to interspecific squash was collected on 2 dates. Fruit was picked and weighed individually. Yield was collected from three representative areas throughout the field. Misshapen or non-marketable immature small fruit were not tallied in total yield. Fruit quality data was also collected at this site from a representative subsample of fruit harvested during yield evaluation. These fruit were quartered and

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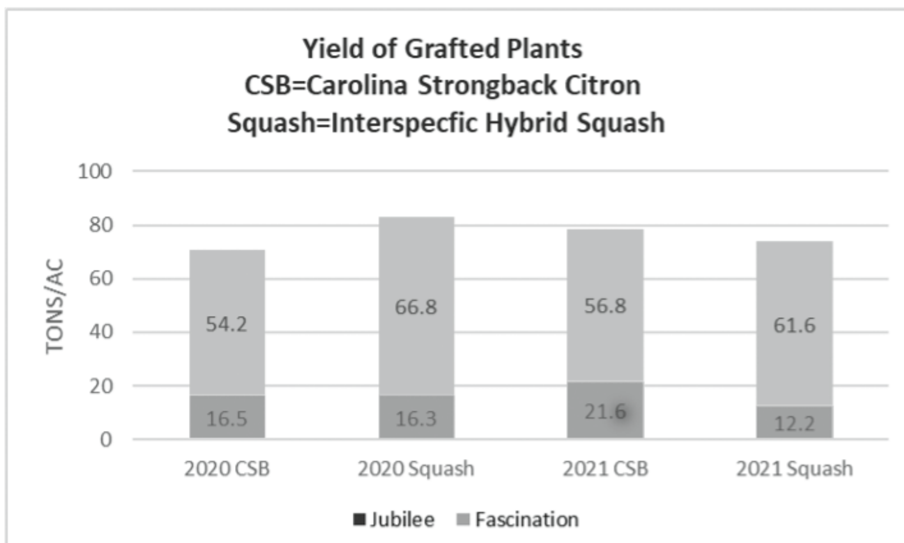
data including fruit weight, rind thickness, fruit length and width, pH, Brix and comments on taste and other fruit features such as hollow heart or pips was recorded.

Summary of Results: In both years, plants of either cultivar grafted to either interspecific squash or citron rootstock performed better than non-grafted plants in terms of viable roots present at harvest and vine condition. Fusarium Wilt was confirmed in non-grafted plants after vine run. Grafted plants did not exhibit any symptoms of Fusarium Wilt throughout the season at any location. However, grafted plants were susceptible to phytophthora root and fruit rot. Foliar disease including powdery mildew and gummy stem blight were also present on grafted and non-grafted plants. On average across all three sites, the Fascination plants grafted to either the citron or hybrid squash rootstocks exhibited 96.7% healthy viable roots at harvest compared to only 6.7% healthy viable roots for Fascination own-rooted plants. On average across all three sites, the Jubilee plants grafted to citron had 69.2 % healthy roots and plants on hybrid squash rootstocks exhibited 74.4% healthy viable roots compared to only 7.7% healthy viable roots for Jubilee own-rooted plants.

Root Knot Nematodes (RKN): Plants were evaluated at harvest for root galling with a value of 0 being no galling present and 100 being severe infestation with all root stems affected. Root knot nematode was only present on one farm with sandy loam soil. The plants from either rootstock on the farms without nematodes present did not show RKN symptoms. However, on the infected farm, the interspecific squash rootstock exhibited severe root galling, with an average rating of 100 for Fascination and 75 for Jubilee. The Citron rootstock did not exhibit any root galling with an average rating of 0. In terms of yields, both rootstocks performed well. One explanation may be the high level of attention and management for this field with fertigation and irrigation conducted as needed on a daily basis. Even with severe galling, interspecific squash were able to take up needed water and nutrients to achieve high yields.

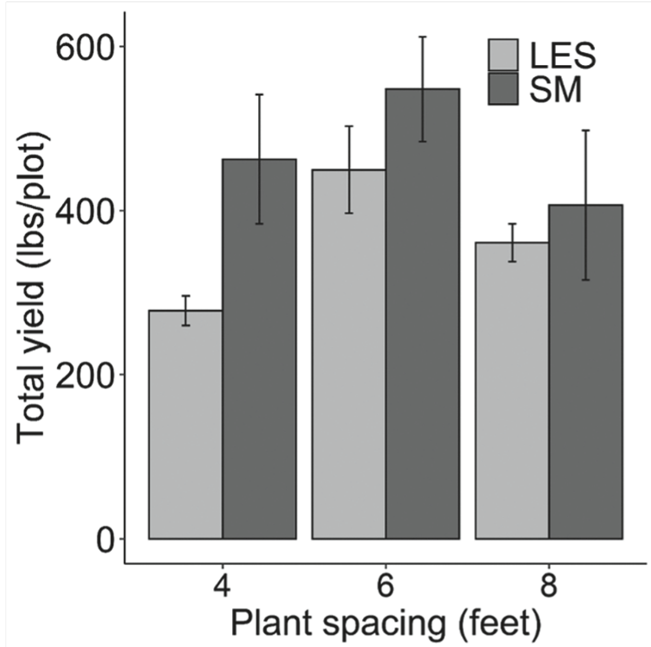


Yield- We are reporting yield data from one farm with consistent yield over both years and only small losses due to phytophthora fruit rot. In 2020, the average yield of the citron rootstock was 78.3 tons per acre whereas the average yield of the interspecific squash rootstock was 73.8 tons per acre. In 2021, the average yield of the citron rootstock was 70.1 tons per acre whereas the average yield of the interspecific squash rootstock was 83.1 tons per acre. Differences in yield between rootstocks were not statistically significant. Own rooted plants did not maintain viable root systems and thus yield data was not collected either year. Losses were near 100% for own-rooted plants both years. The other consequence of poor root systems is the vines from grafted plants eventually “overran” the non-grated plants in the fields.

In summary, plants grafted to either rootstock yielded well and showed excellent resistance to Fusarium Wilt. The Carolina Strongback rootstock showed excellent resistance to root knot nematode, while the hybrids squash rootstock did not. Grafting is a considerable expense and provided no protection for phytophthora fruit rot or for any of the many foliar diseases such as gummy stem blight, anthracnose or powdery mildew.

Population Study 2022

During the 2022 season, a population study was conducted at two locations-one at a private farm in St. Mary's County and the other at the UMD Lower Eastern Shore Research and Education Center (LESREC). Both sites had a history of watermelon fusarium wilt. Seedless Fascination watermelon plants grafted to Carolina Strongback (CSB) citron rootstock were planted at each location with plant spacing of 4ft, 6ft and 8ft between plants and row spacing of 54 to 60 inches. Plots were intensively managed utilizing black plastic mulch, drip tape, fertigation and crop protectants as needed. Each site utilized a complete block randomized design with four replications. The study utilized SP-6 pollenizer plants grafted to CSB rootstock. Data on yield, fruit size, fruit quality and canopy cover was collected.



Summary of Results: The six foot spacing resulted in the highest yields and the highest fruit count at both sites. While this is only one year's worth of data and yields were below average due to the growing season, it appears that the 6 foot spacing is ideal for grafted watermelon. This spacing requires considerably less plants than conventional watermelon spacing. The study also found that fruit size also increased with greater plant spacing, as was expected.

BETWEEN AND WITHIN - REDUCING HERBICIDE INPUTS IN VEGETABLE PRODUCTION

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An integrated weed management (IWM) approach is imperative in vegetable production. Fewer herbicides are registered in vegetables compared to row crops. Furthermore, many herbicides don't offer full-season weed control and producers are at an increased risk of crop injury if not applied as labelled. Farmers consistently list weeds as a top production constraint as they invest great amounts of time and labor to chemical, manual and mechanical weed control. Furthermore, a conflict may arise when deciding on weed management tactics as they may differ depending on where weeds are present. To this end, our research has focused on evaluating IWM approaches that can individually address weed management between and within the crop row.

Between-row

Plasticulture systems offer substantial weed control within the crop row however, the bare soil areas between rows are often exploited by weeds. These weeds reduce crop yield, interfere with harvest, serve as hosts for plant pests and pathogens, and produce weed seeds that affect subsequent crops. Currently, the weeds between plastic-mulched beds are managed with herbicides, cultivation, mowing or manually. However, these tactics are labor intensive and their use can lead to rips in the plastic, increased soil erosion and degradation of soil organic matter. Moreover, applying herbicides after planting is challenging because of the limited number of products registered for vegetable use along with the risk of crop injury. A viable solution to these challenges may include growing a cover crop between plastic-mulched beds. Cover crops such as spring oats and cereal rye are known to effectively suppress weeds. For example, research has shown that spring-seeded cereal rye planted between plastic-mulched beds reduced early-season weed density and biomass. However, it didn't suppress weeds the full cropping cycle. Therefore, the objectives of this study were to: 1) evaluate the use of cover crop management tactics on weed suppression, and 2) evaluate the utility of cover crops for weed management and reducing herbicide applications in plasticulture systems.

To achieve our objectives, we designed a study at the Central Maryland Research and Education Center in Upper Marlboro, MD in plasticulture bell peppers. The study evaluated different combinations of three spring-planted cover crops (cereal rye, spring oats and cereal rye + spring oats), three cover crop termination methods (Gramoxone, Select Max and roller crimped only) and with or without a residual herbicide (Reflex + Dual Magnum). We then collected data on visual weed control, weed species and abundance, cover crop biomass, and crop growth and yield.

Oats produced the most biomass, followed by cereal rye + oats, then cereal rye, with all differences being statistically significant. The results indicated that termination method, residual herbicide application as well as cover crop type influenced percent weed control and pepper yield. Termination with Gramoxone provided significantly better weed control than plots terminated with Select Max or roller crimped at all rating times. A residual herbicide application significantly increased weed control at all rating times. The presence of a cover crop, regardless of species, significantly increased weed control compared to when no cover crop was present. The presence and type of cover crop had a

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significant effect on yield. Mean pepper yield was 100%, 83% and 67% greater in cereal rye + oats, oats, and cereal rye plots respectively, compared to plots containing no cover crop. This study demonstrated that spring-planting a grass cover crop between plastic-mulched beds can be an effective IWM tool. Furthermore, this study also showed that an application of a residual herbicide after cover crop termination is a viable option to increase full-season weed control in plasticulture vegetable systems.

Within-row

Biosolarization may be an effective solution to control weeds within the crop row. Biosolarization is a soil disinfection technique similar to solarization but involves the addition of organic amendments to the soil prior to it being covered with transparent plastic tarp. The tarp facilitates the passive solar heating of the moist, amended soil, promoting the release of allelochemicals and other organic acids into the soil via increased microbial activity. The biosolarization process is performed for about ten days then the tarp is removed and the soil is allowed to aerate for about seven days prior to crop transplant.

Research has shown that biosolarization can increase weed seed mortality and decrease soil pathogens. Moreover, biosolarization is compatible with organic farming practices and can be used in suboptimal climates where solarization wouldn't be effective. Fruit processing by-products (pomace) are promising soil amendments for biosolarization because they are rich in organic compounds, don't pose any biohazard safety risks, and can be relatively abundant and inexpensive. In this study, the biosolarization potential of a mixture of apple and grape (3:1) pomace combined with a between-row living mulch was investigated as an integrated pest management (IPM) technique. Our study objectives were to demonstrate the use of biosolarization, conservation-tillage and cover cropping to: 1) reduce nematode, weed and insect pests, 2) enhance crop growth and marketable yield, and 3) improve soil quality and health.

To achieve our objectives, we designed a study at the Central Maryland Research and Education Center in Upper Marlboro, MD in organically managed eggplant. The study included four treatments comprising of eggplant: 1) grown on living mulch + no-till (LM-NT), 2) interplanted with cover crops (LM), 3) grown in solarized soil (Sol), or 4) interplanted with a cover crop and grown in biosolarized soil (Biosol). In early fall, a cover crop mix (red clover + cereal rye) was planted in all plots however, in LM-NT plots, the red clover and cereal rye were seeded in separate, alternating rows. In the spring, Biosol plots were mowed and the within-row areas were strip rotovated before the biosolarization procedure was performed. Biosolarization proceeded for 12 days then the transparent plastic tarp was removed and the soil aerated for 7 days before eggplant transplant. Data collection included weed counts (species & number) at 2, 4, 6, and 9 weeks after planting (WAP). Soil nematode, beneficial arthropod, natural enemy and epigeal predator counts were taken throughout the season.

The results indicated that Biosol plots had the lowest mean number of broadleaf weeds at all rating times, and grass weeds at 2, 4 and 6 WAP. Broadleaf weeds were greatest in LM plots throughout the study (all rating times). Sedge weeds were significantly greater in Biosol and Sol plots compared to LM and LM-NT plots at all rating times. There were significantly more grass weeds in LM plots than LM-NT, Biosol and Sol plots at 2 and 4 WAP. However, at 6 and 9 WAP, Sol plots contained significantly more grass weeds than the other treatments. The results tentatively show that broadleaf weed seed were effectively inactivated by biosolarization however, sedge control was minimal. This is mainly because of the two different ways in which these types of weeds (broadleaf, sedge and grass) reproduce and emerge. The broadleaf weeds present in plots were all seeded annuals. The main sedge present in plots was yellow nutsedge which is a perennial that reproduces primarily from tubers that grow from rhizomes. Neither solarization nor biosolarization had a negative impact on the tubers of yellow nutsedge. Additionally, the increased tillage and heat generated by the passive solar heating process may have contributed to yellow nutsedge emergence. Conversely, the conservation tillage plots (LM and LM-NT) were better at yellow nutsedge suppression. This may be due to the reduced soil disturbance, especially in the no-till treatment. Also, the soil is kept relatively cool by the cover crop (red clover and rye), which also blocks the light stimuli that's required for the buds on nutsedge tubers to emergence. Grass weeds present in the plots were mainly from foxtails, crabgrass and goosegrass. These grasses are all seeded annuals, therefore biosolarization was effective at inactivating their seeds leading to early-season grass control however, its efficacy decreased substantially by final rating. The results suggest biosolarization may be a viable option for weed management within the crop row. Furthermore, biosolarization can be an effective IWM technique in organic vegetable production.

YIELD AND QUALITY OF SWEETPOTATO GROWN UNDER PROTECTED CULTURE SYSTEMS

Dr. Luis Duque
Penn State

Horticultural-protected culture systems such as high and low tunnels are increasingly adopted across the United States as a flexible and sustainable tool to advance the production of vegetables, small fruits, herbs, cut flowers, and ornamentals. High and low tunnels are especially common as part of the farm infrastructure among small and diversified farms that market their products directly to consumers and/or specialty markets. These relatively low-cost cultivation systems provide an added protected environment relative to the field and allow an extended growing season. The application of protected culture systems such as low and high tunnels to sweetpotato crops in Pennsylvania could address some of the challenges mentioned above contributing to increase yield stability and quality, thereby opening new market opportunities. Production of already available commercial sweetpotato germplasm under high and/or low tunnels could be a profitable enterprise for vegetable growers in Pennsylvania and the Northeast region given the potential season extension afforded by high and low tunnels systems, which could allow growers to diversify their operations and introduce a new crop in their rotation system.

Key findings:

- We tested four different management strategies in combination with four different planting dates: High Tunnel (HT; early May); Low Tunnel (LT; mid-May); Black Plastic Mulch (BPM; early June); and Bare ground (BG; mid-June).
- We tested eight commercially available clones: Bonita, Beauregard, Averre, O' Henry, Hatteras, Covington, Purple Splendor, and Bayou Belle.
- First-year results showed higher total and marketable yield (~700 bu/ac) using BPM compared to all other treatments (~400 bu/ac).
- With regards to sweetpotato categories, all treatments showed increased quantities in U.S. No. 1 compared to all other categories.
- In general, clones showed inconsistent yields under all treatments. However, Bayou Belle showed the highest U.S. No.1 yield under BPM, BG, and LT, while White Bonita showed the lowest U.S. No. 1 yield under BPM, HT, and LT.
- Overall findings suggest that sweepotato clones are adaptable to different management systems, albeit with variable yield and quality attributes.

Dr. Luis Duque - My research focuses on a better understanding of the influence of abiotic stresses on crop growth, development, and yield of storage root crops, mainly potato (Solanum tuberosum Lam.) and sweetpotato (Ipomoea batatas Lam.). In potatoes, we have focused our attention on both heat stress tolerance mechanisms and nutrient use efficiency under prolonged and elevated growing temperatures and low nutrient availability. In sweetpotato, we have examined plant-water relations, phenotypic plasticity, sink-source relations, root system architecture, as well as root quality traits through the use of near-infrared spectrometry (NIRS). Ultimately, our research goals are to accelerate breeding efforts through the use of physiological attributes to improve crop performance and seek ways to alleviate famine and achieve food security. Also, we are interested in novel and common-occurring production management systems for sweetpotato for Pennsylvania and the Northeast.

POTENTIAL BENEFICIAL ASPECTS OF MUSTARD COVER CROP BIOFUMIGATION

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Biofumigation as a remedy for soil borne pests has been studied on numerous crops over the past several decades throughout the US and other countries with mixed results. This presentation will summarize research conducted over three years at the Western Ag Research Station in South Charleston, OH plus one year of on-farm trials in Owensville, OH. There will be three distinct aspects of biofumigation covered: 1) Effects on soil borne fungus *(Plectosporium)* on pumpkin fruit and foliage 2) effects on pollinators and 3) effects on building soil organic matter.

1. Effects on reducing soil borne disease, Plectosporium, on pumpkin fruit and foliage
Research trials were conducted in 2019 and 2020 consisting of five treatments (untreated check, 3 kinds of mustard cover crops, 1 strobiluron fungicide treated w/ no mustard cover crop) in a field where the soil borne fungus *Plectosporium* had been seen in the prior year. This disease can blight the foliage, petioles, vines, fruit rind and handles, making them unmarketable; if left uncontrolled it can kill the plant.

In 2019, mustard cover crops (Pacific Gold, Caliente 199) were sown in the spring and terminated in early summer to allow transplanting of main cash crop pumpkin. Both foliage and fruit were evaluated for *Plectosporium* lesions every 7-14 days starting July 23 through September 13. Major findings included very little damage at the conclusion of the trial; <3% lesions on foliage among treatments and no lesions on fruit, only 3 lesions found on handles. The strobiluron fungicide treatment had the fewest lesions on foliage and petioles. Overall, very dry conditions in 2019 did not favor disease development.

In 2020, the same design in the same field location was used, with the only major differences being the addition of Caliente Rojo as one of the mustard cover crops. Powdery mildew fungicides were also added in the strobiluron fungicide treatment. Results showed all 3 mustard cover crop and the strobiluron treatments had significantly fewer lesions on the petioles and leaf veins compared to UTC. Again, no lesions were found on fruit and low incidence (25%) and severity (1.2%) found on fruit handles. Weather in 2020 was more conducive to *Plectosporium* but still at very low levels.

In 2020, an on-farm strip trial was conducted where strips of Caliente Rojo were spring planted next to non-cover crop strips. The mustard crop was terminated at flowering by mowing and rototilling biomass into soil. The pumpkin crop was direct seeded 10 days after. Results from this field trial showed massive infestations of Plectorsporium on both foliage and fruit regardless of treatment (no differences between cover crop and non-cover crop strips). Final field data included 95% of pumpkin plants were infested with Plectosporium, 80+% of vines collapsed, 80+% of handles severely infested and 25% of fruit severely infested with lesions and unmarketable.

General conclusions about research and on-farm studies includes high variability between years and sites with some evidence for reduction of *Plectosporium* under drier conditions and plots treated with Strobiluron fungicides. Moist summers, high soil inoculum load and susceptible hybrids create worse case scenario for severe crop loss. In general, squash appear more resistant than pumpkin to this disease. The process of using mustard cover crops involves significant management resources and equipment to prepare the field for eventual direct seeding or transplanting,

Mr. Jasinski has been employed by Ohio State University Extension in the Integrated Pest Management Program since 1993. He has a M.S. in entomology from Michigan State University. In 2012 he became the IPM Program Coordinator for the state. For the past two decades he has focused on invasive insect monitoring and vegetable pest management especially cucurbits and sweet corn. Some of his recent projects include herbicide and weed management evaluations on pumpkin, powdery mildew fungicide resistance in pumpkin, no-till pumpkin transplants, pumpkin and squash hybrid trials, biofumigation, cover crops, cucurbit insecticide seed treatments, transgenic and insecticide evaluation for worm management in sweet corn.

thus it is important to understand what value this approach can return to the farm operation. Dry conditions can prevent dramatic disease observations but the use of a recommended fungicide regime can help reduce *Plectosporium* outbreaks.

2. Effects on Pollinators

Honey bee colonies can experience stress and slow growth during periods of dearth during summer and fall when floral resources are scarce in Ohio agricultural landscapes, particularly those dominated by field corn and soybeans. The practice of using cover crops has become increasingly common among growers to aid in overall soil health but also has the potential to provide additional floral resource to relieve honey bee colony stress if those cover crops flower during the dearth periods. To assess this hypothesis, a mustard cover crop strip (0.4 A) was planted in the spring and fall in a landscape dominated by corn and soybeans so that flowering would occur during these periods of scarcity to measure the impact on colony growth. Two hives were placed adjacent to the mustard cover crop (MCC) strip to evaluate if the flowering cover crop can boost colony growth. Two additional hives were placed approximately one mile away in a similar landscape but without the MCC as the control group. Pollen and honey samples collected from the colonies were analyzed to determine what floral resources were foraged by honey bees prior to and during the peak mustard cover crop bloom. A Broodminder under-hive weight scale was installed on each colony to measure weight as a proxy for colony growth. Colonies were inspected to evaluate colony health, brood production, and food stored before and after cover crop blooms. Results from June during MCC pre-bloom found small amounts of MCC pollen in the MCC adjacent hives but not in the control hives. During MCC full bloom 16 days later, up to 18% of MCC pollen was found in the control hives (due to a nearby volunteer mustard cover crop field), although the MCC adjacent hives foraged predominantly on clovers *(Trifolium spp.)* during the sampling time. Broodminder data showed that colonies at both locations followed a growth trend typical in similar corn-soybean dominated agricultural landscapes with no significant extra growth seen in the MCC adjacent hives.

3. Effects on Building Soil Organic Matter

Mustard (Brassica) crops generally grow better under cooler conditions. In this trial, three different mustard cover crop hybrid strips were drilled in spring and late summer with 50 and 100 pounds of broadcast urea. The plants were allowed to grow until flowering and then biomass and height measurements were taken. The plots were then either mowed (removing top growth) or were mowed then roto-tilled to incorporate biomass into the soil to determine the effect on microbial activity and soil organic matter. Dry biomass accumulation in the spring drilled mustard cover crops averaged 2,630 lb / A with 50 lb N added and 3,102 lb / A with 100 lb N added. Dry biomass accumulation was slightly higher in late summer drilled mustard cover crops averaging 3,439 lb / A with 50 lb N added and 4,248 lb / A with 100 lb N added. There was a trend that late summer plantings and higher rates of N increased dry biomass accumulation. Given the number of tractors and types of machinery needed to terminate and incorporate a cover crop in the soil, it's uncertain if the carbon added is greater than the known loss of carbon with soil disturbances such as roto-tilling. By only the mowing the stem and leaf biomass on to the soil surface, not disturbing the roots or soil, may return greater net carbon to the soil versus tillage and incorporation.

Biofumigation may have the potential to allow other crops, not just cucurbits, to be grown in fields where known soil borne pathogens exist. Other benefits of this process include potentially increased soil organic matter and a boon for all kinds of pollinators in the area while flowering. Future research may look at the effectiveness of following a short season soybean crop or wheat crop with a summer mustard cover crop in preparation for the next season's cash crop. It would also be relevant to see the effects of a summer mustard cover crop followed by a spring planting to double the biofumigation effect ahead of a mid to late June crop.

USING COVER CROPS IN ROW MIDDLES FOR WEED MANAGEMENT AND SOIL HEALTH

Alan Leslie
University of Maryland Extension

By definition, cover crops are planted to provide benefits such as preventing soil erosion, improving soil fertility, or building organic matter, but are typically not harvested and sold as a commodity. Within the Mid-Atlantic, cover crops are most prevalently used as an alternative to winter fallow periods in annual grain crop rotations. In these roles they scavenge left over nutrients from the soil profile and protect the soil from runoff and erosion, thereby providing benefits to farmers and local watersheds. However, over the past decade, more advancements have been made in applying cover crops to other production systems to reduce the amount of unprotected bare ground during the growing season, especially in vegetable production systems, where row middles are typically managed as bare ground between plastic rows. Adding cover crops to row middles can provide benefits such as weed suppression and improved soil health, while improving field traffic between rain events and preventing soil splashing on crop plants. In this session, we will provide an overview of research done on several different tactics for applying cover crops to vegetable production systems, and the benefits and potential pitfalls of each.

Figure 1. Peppers transplanted into strip-tilled beds in killed cereal rye cover crop.

Fall-planted winter cover crops are the most widely adopted cover crop system in vegetable and agronomic cropping systems, because they protect the soil and help to build organic matter between growing seasons. Benefits of using winter cover crops have been well documented in terms of suppressing winter annual weeds, building soil organic matter, and improving soil fertility if legumes are included in cover crop mixes. Depending on how the cover crop and the resulting residue are managed, they may also provide benefits to the succeeding crop by smothering weeds with the resulting organic mulch produced by the cover crop residue. In agronomic systems, this has been demonstrated to be very effective when small-grain cover crops are terminated late, after accumulating the maximum biomass possible. Grain crops can then be no-tilled into the resulting mulch, which can be effective at smothering and shading weeds, especially small-seeded broadleaf weeds. Experiments with no-till planting vegetable crops into high-biomass cover crop residue showed similar results, with effective weed suppression when cover crop biomass was high. However, most warm-season vegetables will have stunted growth and reduced yields from the shading effect that the cover crop mulch has on the soil surface early in the season.

Dr. Alan Leslie got his Ph.D. from the University of Maryland studying invertebrate communities in agricultural drainage ditches on Maryland's Eastern Shore with Dr. Bill Lamp. Alan went on to work as a postdoc with Dr. Cerruti Hooks at UMD studying weed management and conservation biological control of insect pests in grain and vegetable systems. Alan is currently working as an Extension Educator in Agriculture and Food Systems with University of Maryland Extension in Charles County. His extension programming incorporates sustainable approaches to insect and weed pests in agronomic and vegetable crops.

Figure 2. Annual ryegrass cover crop planted as livnig mulch between rows of roma tomatoes. The living mulch is managed by mowing regularly.

One alternative to no-till planting into cover crop residue is strip-tillage, where a narrow strip is tilled where vegetable crops are transplanted, while leaving the rest of the cover crop residue intact to suppress weeds in row middles. Strips can be tilled using small rototillers or rototillers modified with reduced blades, or with dedicated strip tillage implements. Strip tillers are typically a single-pass tillage implement, with a straight coulter for cutting residue, followed by a shank for sub-soiling, a pair of disks to form a slightly raised bed, and a rolling basket or other finishing piece to break clods and smooth the bed. In our experience, multiple passes are needed to properly adjust the different components, especially when working in high-residue systems. Strip tillage solves the issue of cooler soils under cover crop residue, however the tilled strips can result in weed escapes in-row, unless effective residual herbicides are used.

Figure 3. Annual grasses and annual grass clover mixes being trialed in drive rows.

One downside to relying on killed cover crop residue to suppress weeds is that this strategy only works with high biomass levels, typically near 7-8 tons per acre of dry material. For winter cover crops, this typically means that termination and other field activities have to be delayed until mid-May in the Mid-Atlantic region. An alternative to working with killed cover crop residue is to maintain a living cover crop between crop rows, in an application known as a living mulch. A living mulch is any cover crop species that grows alongside the cash crop, providing all of the same benefits that a killed cover crop would, but in this case, the benefits are being provided by a living plant, and not by the resulting killed residue. In experiments in Maryland, clover species have been used successfully as a living mulch in vegetable crops, although there are also applications for annual grass species, such as annual ryegrass as well. Clover living mulches are compatible with the strip-tillage method, as many clover species germinate and establish well in the winter, and can be mixed with small grains or other cover crops species. Annual grass living mulches are a method that is especially compatible with typical plasticulture production, as the plastic can be laid following full tillage, and annuals grasses can be broadcast between plastic rows, where they germinate and grow quickly in the spring. The key to using living mulch to suppress weeds between crop rows is to choose a species that establishes and grows well, but not compete with the cash crop. Low-growing species and especially species that tolerate regular mowing are ideal for living mulches, since they can be managed easily to reduce competition with the cash crop.

Recent work at the University of Maryland and Rutgers University has focused on the use of spring-sown cover crops in annual plasticulture systems to manage weeds in row middles. This technique combines some of the benefits of living mulches and killed cover crop biomass, and is compatible with typical plasticulture production. In this system, tillage and bed formation is done in early March, well ahead of when typical warm-season crops will be transplanted into the field. After tillage and bed formation, annual grasses are seeded in the row middles, where they germinate and grow, competing with weeds for space and other resources. To maximize the biomass of the resulting cover crop residue, cover crops are terminated after transplanting the cash crop, using either a roller-crimper, a broad-spectrum herbicide with shielded sprayer, or a grass-selective herbicide. The resulting cover crop biomass and optional residual herbicides applied at termination can provide extended control of weeds in the row middles, while reducing erosion, and providing organic matter to the soil.

Work done at UMD and other universities has shown that there are many different potential applications of cover crops in vegetable cropping systems, and that weed management is only one of many potential benefits from including them in annual vegetable production. Any application of cover crops will increase the potential diversity of plants grown on agricultural soil, the amount of time that the soil is covered by living plant material, and the amount of organic matter entering the soil food web. All of these inputs will contribute to improvements in soil health. Soil health generally refers to the biological functioning of the soil ecosystem, which is directly related to the diversity of organisms in the soil, and the number of links in the soil food web. Cover crops provide a subsidy in terms of both energy and carbon to the soil food web, and sustain the organisms that form the base of the soil food web. Healthier soils will improve the cycling and retention of nutrients, will be more resilient to disturbance, and will have fewer outbreaks of soil pests, as beneficial organisms work to keep pest populations under control.

One of the indirect ways that we can measure soil health is through the composition of the free-living nematode community. Free-living nematodes are very diverse, and different species occupy multiple trophic levels within the food web, feeding on bacterial, fungi, plants, or other animals. The diversity of feeding groups among nematodes makes them effective bioindicators of the overall status of the soil food web. A study of free-living nematodes in no-till soybeans found that fall planted cover crops, whether they are small grain, legume, or mixtures, all improve the structure and increase the complexity in the resulting nematode community. Similarly, in trials combining both living and killed cover crops with strip tillage, the resulting nematode communities that were sampled indicated that the combination of reduced tillage and cover crop inputs improved the structure of the free-living nematode community, and the potential the soil food web to support nutrient cycling.

Figure 4. Red clover living mulch between rows of bell peppers provide energy and carbon inputs to the soil food web during the growing season.

IMPACTS OF WEED MANAGEMENT ON SOIL HEALTH

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Weed management techniques can have significant impacts on physical, chemical, and biological aspects of soil health. This presentation will focus on several experimental comparisons of non-chemical weed management practices.

In onions, winter squash, and conifer trees, I have led or co-led side-by-side comparisons of cultivation-based weed management to mulch-based approaches. There is obviously more soil disturbance in cultivation-based systems, which can degrade soil structure, cause soil compaction, negatively impact soil arthropods, and increase oxidation of soil organic matter. The churning of the soil can also bring up more weed seeds from deeper levels and stimulate their germination. In one out of two years in an onion experiment, soil microbial biomass (a measure of soil health) varied depending on the intensity of cultivation – in frequently cultivated, weed-free plots it was decreased compared to plots that were infrequently cultivated or mulched with natural materials. However, there are practical benefits of cultivation that are difficult to pass up. It is often less costly and labor intensive than mulching. Soil disturbance provides an unfavorable environment for slugs, and it can increase the soil temperature and quicken oxidation of soil organic matter to provide a timely release of nitrogen for crops.

Black or otherwise opaque plastic mulch film generally provides excellent weed control if it is laid on smooth planting beds and planting holes are kept small. Crop yields in plastic mulch systems are often increased due to the weed-free conditions, the elevated soil temperatures, and relatedly, the increased mineralization of nitrogen from soil organic matter (in one experiment, end-of-season nitrate was several times greater than in nearby systems). Silver, reflective plastic mulch can interfere with the navigation of some insect pests, such as thrips. But there are some downsides to plastic mulch. Some perennial weeds, such as yellow nutsedge, may be able to penetrate plastic mulch and it can be challenging to control weeds emerging from the edge of the mulch with cultivation, therefore, herbicides, natural mulches, or brush weeders may be needed in that zone. Plastic mulches also typically require drip irrigation. Most plastic mulch is removed and disposed each year, but some initial research at other universities suggests that abrasion and photodegradation can cause some quantity to break down into microplastics, which may be absorbed through crop roots. The effects of microplastics on human health is still a developing area of research.

Mulches of natural materials, such as hay, straw, woodchips, or cover crop residue, can provide excellent weed suppression if applied at a sufficient rate. For season-long weed free conditions, research suggests that 18,000 pounds per acre is needed. However, decent suppression can be obtained with lower rates. In our work evaluating different levels of rolled winter rye cover crop mulch, 7,000 pounds per acre provided 87% control of the primary weed in the field, tall waterhemp. That level of rye biomass represents what can be reliably achieved in fertile soils of NY. In unfertile soil, 3,500 pounds per acre can be reliably achieved, which provided 73% control of the tall waterhemp. Although natural mulches effectively suppress emergence of weeds germinating from seed, most perennials will have sufficient energy reserves to penetrate these mulches. Annual tillage can help keep perennials from dominating regularly mulched fields. This is best done in the fall since mulches incorporated immediately prior to planting can severely stunt the crop due to mix of nitrogen tie up and allelopathy. Likewise, mulching too early can prevent the soil from warming and stunt crop growth. These factors are also at work in rolled rye cover crop mulches, in addition to soil compaction. We have trialed rolled rye mulch in several vegetable crop systems but have been unsuccessful in overcoming these challenges thus far and yields have been dramatically impacted. But these impacts are lessened when mulches are applied to established transplants after the soil has warmed. And there are some excellent soil health benefits to using natural mulches– the soil is covered, which limits erosion and water loss, and the addition of organic matter

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will improve the soil over time. One collaborating vegetable farm that regularly applies natural mulches had increased their soil organic matter to over 20%, which now supplies most of their fertility. Likewise, earthworm populations typically increase under natural mulches, which may improve water infiltration. On the other hand, we have found that weed-seed-eating Carabid beetles are less numerous in natural mulches than plastic mulches or vegetated unmulched systems.

For this presentation, I also quickly summarized several reviews of previous research on the impacts of herbicides on soil biota and found that, for most herbicides, effects are minimal if used at labelled rates, especially when compared to insecticides or fungicides.

Overall, weed and groundcover management has a substantial impact on soil physical, chemical, and biological properties. Managing weeds with soil disturbance, plastic mulch, or natural mulches each have distinct tradeoffs.

WHAT WAS LEARNED FROM OVER 20 YEARS OF EVALUATING BIOFUNGICIDES

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In 1994, when I started evaluating biofungicides for diseases of vegetable crops, there were very few products on the market. First products tested were Kaligreen and Armicarb (potassium bicarbonate), AQ-10 (biocontrol; discontinued) and Milsana (plant extract; today marketed as Regalia). There now are a large number and diversity of products, at least as many as conventional fungicides. The active ingredient in biopesticides are natural substances. I have information about biopesticides and crop lists of products with labeled diseases at https://www.vegetables.cornell.edu/ipm/diseases/biopesticides/. Most of my evaluations have been for cucurbit powdery mildew. I have also determined efficacy of biofungicides for cucurbit downy mildew, Phytophthora blight, basil downy mildew, and foliar diseases (Septoria leaf spot and powdery mildew) of tomato. I have lists of products I have tested with summary statements about their efficacy at https://blogs.cornell.edu/livegpath/research/organic-disease-management/. Full reports are available to download there. Most evaluations have been biopesticides applied solely. More recent research has included programs with more than one biofungicide and programs with conventional fungicides, and biofungicides applied to resistant varieties. I also have photographs posted from recent evaluations.

In addition to my results, I have efficacy results from reports published by other researchers at https://www.vegetables.cornell.edu/ipm/diseases/biopesticides/ in a downloadable excel file posted under 'More information'. Since it is an excel file, the contents can be sorted by crop, disease, product, and/or efficacy. I recommend focusing on efficacy calculated from the data which is in columns V – Y. To facilitate, use the hide command to hide at least columns J – U. A treatment is labeled as effective (assigned 'E' and highlighted green in columns W and Y) when the treatment disease rating is significantly different than the untreated control (the two treatments have different mean separation letters from statistical analysis). It is valuable to also look at calculated % control in columns V and X. Sometimes, while effective, the level of control is low (less than 10%) and sometimes, due to high variability in an experiment, a biofungicide is ineffective although control was greater than 50%.

Interest in biofungicides stems from their positive attributes, in particular their low toxicity and low potential for resistance to develop in target pathogens. Low toxicity means they typically have short re-entry interval (REI) and pre-harvest interval (PHI), offering growers flexibility in harvest operations. Most biopesticides have been granted an exemption from the requirement of a tolerance, aka maximum residue level (MRL), which is the legal limit for a pesticide chemical residue in or on a food. Combined with low potential for resistance development means there are no limitations on number of consecutive and total number of applications as there are for most conventional fungicides. While toxicity typically is low, before using any biopesticide, check the precautionary statements on its label to find out what personal protective equipment (PPE) is required for those handling the product and whether it has potential to affect birds, pollinators and other beneficial insects, and mammals.

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

What I have concluded about biofungicides from my experience evaluating them and from results of research conducted by others includes:

1. Biofungicides for foliar and fruit diseases have contact activity. Therefore, it is best to use a preventive (proactive) application schedule, second best is to start when symptoms first seen, and also to strive for thorough coverage especially of the lower surface of leaves. Also reapply on a regular (e.g. weekly) schedule and after rain. There are claims of disease resistance being activated in treated plants for some biofungicides, in particular those with a Bacillus species as the active ingredient. Two metabolic pathways involved in resistance are the salicylic acid pathway which results in systemic acquired resistance (SAR) and the jasmonic acid pathway which results in induced systemic resistance (ISR). Model plant systems such as Arabidopsis have been used to document activation of one of these pathways following application of a biofungicide. There is need for research examining resistance activation in a diversity of crop plants to a diversity of pathogens under field conditions. From my experience testing biofungicides for cucurbit powdery mildew mostly in pumpkins, it does not appear that resistance is being activated or it is not effective for this disease based on the fact I have documented control on the upper surface of leaves with a diversity of biofungicides, but not on the lower leaf surface where it is difficult to directly deliver spray material due to leaf size and canopy architecture.
2. Biofungicides, like most conventional fungicides, do not have the ability to cure infections. Start applications before infection for maximum efficacy.
3. Biofungicides generally are good components of an organic management program, providing a useful alternative to at least some copper fungicide applications. Phosphorous acids (phosphontes) are among the very few biofungicides not approved for use in organic production.
4. Applying different biofungicides together or in alternation might be the most efficacious approach to managing diseases.
5. Biofungicides have good potential for managing bacterial and root diseases in conventionally as well as organically-grown crops because there is a lack of effective alternative products.
6. Biofungicides generally are not as effective as modern, targeted conventional fungicides.
7. Best approaches to incorporating biofungicides into a conventional fungicide program to reduce use of conventional fungicides are to apply biofungicides in place of contact (protectant) fungicides (ex. chlorothalonil) in the program and in place of targeted conventional fungicides for the last applications to a crop.

Recommendations to maximize success using biopesticides to manage plant diseases:

1. Check efficacy data when selecting products to know what to expect. Look for data from field evaluations; products generally perform better under controlled laboratory and greenhouse conditions than outdoors. Note that efficacy is not considered by US EPA when making registration decisions.
2. Make sure target diseases have been correctly identified. I have tips on diagnosis at https://www.vegetables.cornell.edu/pest-management/disease-factsheets/general-tips-on-identifying-plant-diseases/.
3. Check expiration date before purchasing a biopesticide, especially those that have a microbe as the active ingredient, to ensure it is still good and the contents can be used up before that date. Follow label storage recommendations to ensure product maintains activity.
4. Use biofungicides as a component of an integrated management program with cultural practices such as rotation, pathogen-free seed, resistant varieties, sanitation, weed control, etc. Also check crops each week for disease symptoms as well as insect pests. Keep dated notes about what seen and take photographs.
5. Use preventive application schedule based on disease occurrence in crops during pervious years.
6. Apply biofungicides in a way that maximizes spray coverage on all leaf surfaces. Drop nozzles can be very effec-

tive, especially with crops like tomato and pepper. Nozzles can also affect coverage. Use water sensitive paper to assess coverage. Apply such that there is no runoff because amount of spray deposit is more just before runoff than afterwards.

7. Use a regular (weekly) schedule with applications adjusted based on weather and conditions. Apply before rain rather than after because most fungal and bacterial pathogen infect when plant tissue is wet. Re-apply after an intense rain with about 2 inches of rainfall because this will remove a lot of residue. Applying more frequently than once a week may also be warranted when conditions are very favorable for the target disease.
8. Determine best use patterns for biofungicides by reading the label, checking company website, and asking company technical staff. For example, an adjuvant may be recommended, in particular a spreader/sticker. Spray solution pH can affect product performance: pH between 6 and 8 is best for most microbial-based biofungicides. There may be conditions (e.g. temperature, time of day) that are best for making an applications or to be avoided. Also check about compatibility of potential tank mixtures. Copper fungicides can be a good partner including with many microbial-based biofungicides, but not all. The container for liquid formulations should be shaken well right before use because settling can occur.
9. Knowing the mode of action of biofungicides (how they work) can be useful.
10. Assess control obtained. I suggest taking photographs and jotting down a description of disease severity observed 7-10 days after the last application. Also note how favorable conditions were for the disease. Unfavorable conditions (ex. few rain events) can be the main reason for limited disease development.

CONTRASTING INSECT BIOCONTROLS IN TUNNELS VS GREENHOUSE PRODUCTION

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Protected environment production is a popular and efficient way to produce crops year-round regardless of the environmental conditions outside of the production structure. Traditional greenhouses are a common and familiar tool for controlled environments but are costly to build. A more accessible method of protected culture includes high tunnels, hoop houses or caterpillar tunnels. These structures provide protection to the crops grown beneath, but do not facilitate nearly as much control over the growing conditions within the structures. In relation to insect and mite pest dynamics, the environment within tunnels and greenhouses are very different. Greenhouses are more tightly controlled with fewer openings to the external environment and therefore the pests that infest them are often small and soft-bodied (e.g., mites, aphids, and thrips). High tunnels or hoop houses are much more open to the external environment. Because high tunnels are a hybrid between open-field and greenhouse systems, pests that are associated with each of these growing systems can be found under high tunnels. Common targets for pest management under tunnels include soft-bodied pests that benefit from rainfall protection, in addition to caterpillar pests and herbivorous beetles that are prevalent in open-field production.

Augmentation biological control, the strategy of purchasing and releasing natural enemies into the growing environment, is feasible because of the thriving industry that provides natural enemies for pest management that has largely benefited the greenhouse industry. There is a need to translate and adapt methodologies used in greenhouses to high tunnels that are much more open during the peak growing season. So far, achieving this has not been as straightforward and successful as initially expected.

Despite much of the Extension literature suggesting the transfer of greenhouse IPM to high tunnels, there is very little research that has been conducted to evaluate the efficacy of biological control strategies utilized in greenhouses applied to high tunnel systems. The work that we have conducted suggests that the extreme heat experienced in high tunnels during the peak growing season is unsuitable for many agents, limiting their efficacy to suppress pests. The open nature of high tunnels in the peak of the growing season also facilitates high rates of dispersal of augmented natural enemies out of the tunnel.

The seasonality that is inherent with high tunnel systems, and a limited capacity to manage the abiotic conditions in comparison to greenhouses requires additional research. However, there are some recommendations that can be made based on our current understanding of biological control programs. Organisms that are effective in greenhouse systems for the management of thrips, aphids, mites and other soft-bodied insects, that are limited in their dispersal capabilities are likely to be more successful in high tunnels. This would include predatory mite species and immature stages of organisms such as lacewings, ladybeetles, and the minute pirate bug. Our research has shown that adult stages of these insects disperse from the tunnel within 24-48 hours of deployment. By incorporating the immature stages you can benefit from their pest suppression while they mature, with the expectation that they will

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leave once they reach adulthood. We have shown that incorporating cut flowers and the herbivore-induced plant volatile lure (Predalure®) can increase the retention of minute pirate bugs. Temperatures can reach lethal highs in high tunnels, where ventilation is limited, and may therefore result in the failure of biological control during the hottest times of production. In any case, we anticipate that more releases may be necessary compared to greenhouse systems, to achieve pest control.

Exclusion netting, which has been applied to both greenhouse and high tunnel ventilation systems, is another effective tool for pest management. In greenhouses, fine mesh screening, such as those that have a pore size small enough to exclude thrips and mites, can be installed as a pest management tool. These structures are equipped with active cooling systems which can counter the reduced airflow through the vents from the mesh. In high tunnels we have seen that you need to increase the pore size of the mesh to maintain adequate ventilation. In these systems, insect netting with a pore size of 400 x 450 µm reduced ventilation to a point that the temperature became too high for plant growth. Increasing the mesh pore size to 0.72 x 0.97 mm or larger did not impact temperatures and relative humidity inside the tunnels and this pore size is effective to exclude larger leaf-feeding herbivores, such as the striped cucumber beetle.

While we encounter parasitoids naturally colonizing high tunnels, along with predatory midges and syrphid flies, no work has been done to evaluate augmentative releases of parasitoids for pest management. Banker plants, a common strategy employed in greenhouse systems to maintain prey items and natural enemies, have also not been evaluated in high tunnel systems. This strategy may be effective, but the main concern of abiotic factors likely limits the conventional hanging basket integration of banker plants. More research is needed to evaluate the integration of banker plants in high tunnels along with strategies to enhance conservation biological control. Given that we have encountered colonization by natural enemies such as spiders, syrphid flies and parasitoids, there may be opportunities to conserve and promote their colonization.

USING SUFFOIL-X TO MANAGE ARTHROPOD PESTS: LITERATURE REVIEW

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Introduction: SuffOil-X® is an insecticide, miticide and fungicide that suffocates pests. It is a unique 80 % pre-emulsified high paraffinic, low aromatic horticulture mineral oil. Approved for organic production, it is the ideal choice for effective insect, mite and disease control in a broad range of greenhouse, nursery and vegetable crops. This session covers the versatility of this product and provides a literature review of new as well as older published and unpublished data on the following pests and crops: green peach aphids on peach, chili thrips on bell pepper, sweetpotato whitefly on tomato, red spider mite on apple and twospotted spider mites on strawberry and tomato. Further research details covered in the presentation can be found below. References are provided for a full description of the methods and products tested. Reach out if you require additional information.

Presentation/Literature Review Take Home Points:

1. SuffOil-X® offers effective management of arthropod pests on a variety of crops.
2. SuffOil-X® 80% oil concentration offers arthropod control with less oil applied which subsequently provides improved crop tolerance compared to products with higher oil concentrations.
3. Horticultural- and essential-oils kill arthropods and beneficial insects on contact, however, compared to chemistries, oils have no residual and natural enemy communities will quickly repopulate.
4. Rotation of oil-based products like SuffOil-X® with chemical modes of action can prolong chemical efficacy and reduce resistance development.
5. SuffOil-X® offer safer and more environmentally friendly alternatives to conventional pesticides.

Green Peach Aphids

A field test was conducted to evaluate the efficacy of organically acceptable foliar insecticides for control of green peach aphid *(Myzus persicae)* on young peach trees *(Prunus persica)* under New Mexico conditions. The experiment was conducted as a randomized complete block design with five single-tree replicates per treatment. Aphid populations on the experimental trees were assessed by counting all individuals on the two apical leaves of five randomly selected shoots per tree. SuffOil-X® was slow to take effect but gave control comparable to Azera® by 7 days after treatment.

Grasswitz T.R. (2014). Field evaluation of organically acceptable foliar insecticides for control of green peach aphid. Arthropod Management Tests, Vol. 39

Chili Thrips

This trial evaluated alternative microbial insecticides and SuffOil-X® for control of chili thrips *(Scirtothrips dorsalis)* on pepper *(Capsicum annuum)*. The study was conducted in a greenhouse at the Mid Florida Research and Education Center. Tree applications were applied as foliar sprays using a hydraulic sprayer. Sampling was conducted over five weeks. Average numbers of adults and larvae per plant were obtained from the three most terminal leaves. The final count was negatively affected by large numbers of thrips exiting control plants and infesting other experimental cages. All treatments reduced numbers of adult and larval thrips.

Julie Graesch is a Biological Program Manager for insect management at BioWorks responsible for technical support to internal and external stakeholders. Julie has 16 years of experience as a biological scientist and entomologist, practiced in laboratory, greenhouse, and field research as well as biological technical service support for the integrated pest management industry. She has a B.S. degree in Biology and a Master of Agriculture degree with a focus in Entomology from Iowa State University. She has been with BioWorks for 3 years and has previously held positions at BASF, Becker Underwood, and Iowa State University.

Arthurs S., and Aristizabal L.F., (2011). Low risk insecticide trial for thrips control on bell pepper. Arthropod Management Tests, Vol. 36

Sweetpotato Whitefly

This trial evaluated foliar sprays for preventative and knock-down control of sweetpotato whitefly *(Bemisia tabaci)* on greenhouse tomato *(Lycopersicon esculentum)* compared to a nontreated check at the Gulf Coast Research and Education Center, Wimauma, FL. Two weeks after all treatments were applied, SuffOil-X® was applied a second time. Sampling was performed weekly and consisted of 10 randomly selected, mature leaflets per plot. The sum of all instars was lowest with treatments of SuffOil-X®. Chemical treatments numerically decreased but were not statistically different from the nontreated check.

Smith H.A., and Nagle C.A. (2015). Control of sweetpotato whitefly with foliar applied insecticides in greenhouse tomato. Arthropod Management Tests, Vol. 40, No. 1-3

European Red Spider Mites

This trial evaluated foliar sprays of SuffOil-X® compared to PureSpray™ Green and an untreated control against European red spider mites *(Panonychus ulmi)* on two varieties of apple *(Malus domestica)*. Four spray applications were made 10 days apart. Mite counts preceded spray treatments. To assess effects of treatments, a branch beating technique was used to dislodge mites onto a large white collection tray. Results showed both oils effectively reduced populations of mites on Cortland and McIntosh apples. In August, red mite populations naturally declined as natural predator populations built up demonstrating oil compatibility with natural enemy communities.

Unpublished data: Coupland J., (2021). SuffOil-X® efficacy trials against European red spider mites on apples. FarmForest Research Inc., Carp Ontario Canada.

Twospotted Spider Mites, Strawberry

Greenhouse and field trials evaluated foliar sprays of SuffOil-X® compared to PureSpray™ Green and an untreated control against twospotted spider mites *(Tetranychus urticae)* on strawberry *(Fragaria Sp.)*. Three spray applications were made every seven days. Mites were counted on five leaves (greenhouse) and 20 random leaves (field) per plot before the first application to give a base mite infection per plant. Two days after each application mites were again counted on five leaves per plot (greenhouse) and 20 leaves per plot (field). Both greenhouse and field trials resulted in both oils substantially reducing mite populations.

Unpublished data: Coupland J., (2022). To determine efficacy of SuffOil-X® on the control of twospotted spider mites in field grown June bearing strawberries. FarmForest Research Inc., Carp, Ontario Canada.

Unpublished data: Coupland J., (2022). To determine efficacy of SuffOil-X® on the control of twospotted spider mites in greenhouse strawberries. FarmForest Research Inc., Carp, Ontario Canada.

Twospotted Spider Mites, Tomato

Field trial evaluation of biorational products; mineral- and essential-oil foliar sprays as well as predatory mite Phytoseilus persimilis alone and applied in rotation with oils against twospotted spider mites *(Tetranychus urticae)* on tomato (Solanum lycopersicum BHN 602). The study was conducted in high tunnels at Chilton Regional Research & Extension Center, Clanton, AL. Six weekly spray applications were made, and plots were evaluated once a week by sampling five randomly selected leaves per plot for eggs, nymphs, and adults. Results show Phytoseilus persimilis, and oil-based bioinsecticides alone or in rotation offer effective control of spider mites.

Mertoglu G., (2019). Evaluation of biorational insecticides against twospotted spider mite (Acari: Tetranychidae) on Tomato. Thesis submitted to Graduate Faculty of Auburn University.

INSECT MANAGEMENT IN VEGETABLES

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Insect pests are as diverse as the vegetables they infest, feeding on the roots, stems, leaves, and reproductive structures. The foundation of any pest management program is anticipating and identifying threats before and as they come. Vital resources include but are not limited to extension agents and university resources, association newsletters, and production guide literature. Scouting, pest identification, and record keeping is critical for selecting appropriate responses. Integrated pest management is a management philosophy that has proven economic, production, and environmental benefits. However, it requires a thorough understanding of the target pest, its biology, and how it interacts with other components of the system. Within an IPM framework, there are multiple strategies a producer can use to limit pest damage, ranging from low input cost, preventative, and low system disruption to generally more disruptive rescue treatments.

Cultural strategies include planting times, cover crop, weed, and soil management, and varietal selection. Certain pests are favored by early plantings and cool, wet conditions when plants are growing slowly. For example, slugs are favored by no-till, high residue conditions but seedcorn maggot are favored by tillage. Varietal resistance exists to some vectored viruses and in the case of sweet corn, certain Lep pests. Cover crops may enhance or exacerbate pest issues while also providing habitat for beneficial insects. Physical strategies include screening, row covers, and adjusting abiotic factors.

There are numerous pathogens and beneficial insects that feed on certain insect pests. Perhaps the most recognizable are those that destroy aphids. Other important pests for which biological control agents play an important role in moderating their impact to a crop include caterpillars, spider mites, and thrips. Conserving beneficial insects can be achieved by providing floral resources to those species that visit flowers, providing alternative non-pest hosts, and reducing broad spectrum insecticide application. University extension resources can assist producers in identifying methods to integrate insecticide and biological control strategies by means of selection, timing, and rates. Other benefits to fostering biological control include preserving pollinators which can contribute to positive yield increases in pollinator-dependent crops such as cucurbits and tree fruit.

Chemical management is perhaps the most powerful and disruptive management strategy, appropriate for when pest economic loss is imminent. Many, but not all pests do not cause significant crop damage below a certain population level called an economic threshold. Once that threshold has been reached, the expense of pesticide management is outweighed by potential crop injury reduction. Insecticides are classified into mode of action groups and are designated on product labels. The most common groups (1A carbamates, 1B organophosphates, 3A pyrethroids, 4A neonicotinoids, 5 benzoates, 6 spinosyns, and 28 diamides) will be discussed, along with notes on other, less used but more pest targeted groups. Much consideration needs to be done when using pesticides, not just for handler and consumer safety but also to avoid negative consequences such as secondary pest outbreaks and a wasted application due to target pest resistance to the selected product. Combining all of these tactics and strategies can aid producers in reducing the impact of insect pests. It is also important to recognize that some pests are more amenable to a particular strategy while others are much more difficult to management with existing tools.

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

DEVELOPING YOUR WEED CONTROL PROGRAM

Tim Elkner
Extension Educator, Penn State Extension, Lancaster County

Controlling weeds is critical to the success in producing any vegetable crop. Weeds will compete for light, nutrients, water and space with your crop and in most cases are able to out-compete the crop. In addition, tall and or thick weeds will interfere with proper insecticide and fungicide coverage during pest management sprays. There are several pieces of a successful weed control program and failure in any one area can collapse the entire process. Good weed control is a combination of cultural as well as chemical methods and each method must be properly timed to be most effective.

Start by arming yourself with knowledge! Purchase - and read - a copy of the current Mid-Atlantic Commercial Vegetable Production Recommendations Guide. Get a good weed identification guide with color photos like "Weeds of the Northeast" (a new edition is being released soon). Attend grower meetings like this as well as local dealer and Extension-sponsored meetings and get to know other growers and commercial suppliers as well as your Extension local agent. Plan to attend summer on-site meetings when offered to further increase your knowledge.

Next – start your weed control program by taking soil test(s). Vegetables will grow poorly in soil that is not at the correct pH or is low in fertility. Both fertility and pH are most easily corrected before the crop is planted, although some fertilizer can be added during crop production. Vegetables growing in soil with the correct pH and fertility are more effective in competing with any weeds that may be in the field.

Follow by taking an inventory of the weeds present in the field you are going to plant in as well as investigating the history of problem weeds. Perennial weeds are challenging to control when the crop is growing so they should be eliminated before planting any vegetables. It may take several months or longer to control some persistent weeds such as Canada thistle so give yourself this needed time before planting.

Knowing the history of problem weeds in a field is also necessary in planning your herbicide program – what materials will need to be applied at what time in the season (spring, summer or fall) to manage these weeds? Another advantage of knowing the problem weeds in a field is that this information may help you select where to plant certain vegetable crops. If grassy weeds are a problem then you might consider planting a broad-leaved vegetable there so you can use the grass management herbicides as needed.

Now consider equipment – what types of tillage implements will you need for weed management? Cultivation for weed management is not as common as it once was but is being successfully used in many instances and has some advantages on the farm. These include elimination of re-entry and pre-harvest intervals as well as the elimination of drift and carry-over concerns. There disadvantages to using tillage including the importance of proper timing of tillage operations as well as challenges with tilling during a wet year. Tillage equipment is diverse and can get expensive so if you plan to use this method of weed control do your research first – including talking with other growers who till - for tips and concerns.

Selection of the proper sprayer for weed control is another critical part of your weed management program. It should be flexible enough to make both broadcast as well as banded applications and sized to fit both your growing operation as well as equipment available to pull/power it. Recommendations for other growers as well as research will help you make this important choice. Whatever sprayer you choose be sure to calibrate it properly at the beginning of each season as well as during the season if needed. Ideally you will have two sprayers on the farm – one for herbicides and another for insecticide and fungicide applications.

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

Finally – familiarize yourself with the herbicides that are labeled for the crops that you plan to grow and their time of application in the crop cycle. Preplant, preplant incorporated, pre-emergent, post emergent – all different materials with different application timings that need to be applied at the right rate to the right location. What types of vegetable do you plan to grow? Ideally you will select herbicides that can be used on as many of those crops as possible to help reduce expenses. Again – other growers, Extension agents and chemical dealers can provide recommendations and advice for developing your herbicide program(s).

As you develop your herbicide programs, be sure to plan for as much herbicide class rotation as possible. Resistance can develop in the weeds you are trying to control (just like with insecticides and fungicides) and can result in some difficult to control weeds on your farm. In addition, consider the residual or plant-back restrictions that are associated with the herbicides you plan to use. Some materials provide very effective season-long weed control but often these materials come with restrictive plant-back regulations so know in advance what you plan to plant in a given field the next season to be sure that you do not disrupt your vegetable crop rotation schedule.

And finally – do not forget about post crop weed control. Many weeds are capable of producing hundreds or even thousands of seeds when they mature and those seeds, if they fall in your field, can be future season weeds that will need to be managed. So a critical piece of your season-long weed control program is to prevent as many weeds a possible from producing seeds. Soils have a a 'seed bank' that will allow for new weeds to germinate over a period of many years and you should not make any new deposits there!

BASIC SEASONAL NUTRITION IN SOLANACEOUS CROPS

Steve Bogash, NE Territory Business Manager, ProFarm Group

Packable tomato yields of #20 plus pounds per plant are readily attainable by growers willing to focus on production details. However, fruit cracks, shoulder checks, radial cracking, yellow shoulder, and blossom-end rot are all serious defects in tomato fruit which in turn will result in losses in the quantity of marketable fruit. There are a number of cultural practices that growers can implement to dramatically decrease these problems. Proper irrigation management, careful attention to balancing specific nutrients, and the use of either plastic or organic mulches have all been proven in field trials to significantly increase fruit quality.

While weather is a factor that remains beyond growers control, shelters such as high tunnels have been shown in trials to be "unusually effective" at increasing fruit quality through reducing rain splash on fruit and even improving light quality when using 'diffusion-type' plastic films. Episodes of fruit cracking often follow rain especially in larger fruit. In addition, keeping rain off the foliage all but eliminates a number of fungal and bacterial diseases by keeping the leaves dry and preventing rain drop splashing-caused movement of plant disease spores. Spider mites, Aphids, Thrips, Leaf Mold and Early blight remain common pest challenges for shelter-grown tomato plants.

In order to produce the greatest quantity of the highest quality tomatoes (peppers too) growers must:

1) Pay careful attention to soil preparation prior to planting. In the case of soilless media, the selection of the appropriate media has long term consequences for the management of plant nutrition.
2) Select only those varieties that perform well and meet individual grower market requirements.
3) Understand their water resources thoroughly as pH and alkalinity have direct implications in water treatment and the selection of nutrients.
4) Use moisture sensing soil appliances such as tensiometers in order to meet plant water demands as growing conditions change.
5) Plan and implement a regular and consistent program to test soil and plant tissue to meet changing plant demands.
6) Have a well-designed, easy to maintain, well maintained, nutrient injection system. Most injectors require a rebuilding at least every other year in order to maintain accurate proportioning. This is especially important with acid injection systems as even minor changes due to wear can have a great impact on nutrient availability
7) Be prepared to apply nutrients on a regular basis to meet plant demands. This includes foliarly applied nutrients.

Preplant soil preparation

The first step in creating a high yielding, high packout tomato and pepper crop is preplant soil testing. Fruiting vegetable crops remove substantial quantities of nutrients, so test annually in order to use the best information in applying the coming years' nutrients. Based on soil analysis results, conventional growers will need to incorporate at least 30-50% of nutrient requirements at soil preparation. Organic growers will want to incorporate 70-80% as organic fertilizers for injection post planting are substantially lower analysis in N, P, & K versus conventional powdered concentrates. Slower release fertilizers such as greensand, green potash, and burnt potash as potassium sources, aragonite as a calcium source and magnesium sulfate (Epsom salts) applied at plow down have demonstrated high potential to further reduce Blossom End Rot and Yellow Shoulder.

Water resources, pH and alkalinity

Tomatoes and peppers have the best nutrient uptake at a soil solution pH of 6.2-6.5. This will maximize potassium uptake as well as create a situation where it is possible to keep all of the other nutrients in the high end of the 'sufficient'

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. In 2022, Marrone Bio became the Pro Farm Group Inc. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

zone. Regular testing of your irrigation source for pH and alkalinity will provide you with the information to adjust your pH through the addition of acids. Note: low pH is seldom a problem, but where the irrigation solution pH is below 5.8, the use of alkaline fertilizers is indicated. The injection of alkaline materials specifically for pH adjustments such as calcium carbonate or potassium bicarbonate is only recommended where the pH is below 5.5. Sulfuric acid is the most common material used to reduce pH and alkalinity. Organic growers have had good success with citric acid for pH reduction. Seven to nine ounces of powdered citric acid per 100 gallons of irrigation water will reduce the pH of most water by about 1 full point on the pH scale. Conventional growers can use the AlkCalc alkalinity calculator to get extremely close to a proper dose. The use of a calibrated pH meter is highly recommended to test the irrigation stream regularly as the online calculator and citric acid recommendation are simply tools to get close to the target pH. Water pH often changes during the growing season based on rainfall and source. Limestone aquifers can experience an increase in pH and alkalinity in a dry season as the underground storage area decreases. Surface waters will change with every rain event as rainwater combines with runoff.

Note on the pH scale: *Even small incremental changes in pH mean a lot for soil solution chemistry. This is because the scale is logarithmic. The difference between a pH of 6 and 7 is ten-fold. Going from a pH of 6 to 8 is 10 x 10 or 100 fold. Most tomato growers that have adopted acid injection find that their crop quality improves dramatically as their potassium utilization improves.*

Note on pH meters and litmus paper: Litmus paper is nearly useless for accurate water testing as it will age rapidly once the package is opened and is only designed to get within ½ of a pH point. The author regularly finds litmus paper tests to be off by 1-2 points. Purchase a high quality digital pH meter that self-temperature adjusts, read the directions carefully, change the batteries at least annually and use fresh pH 4 and 7 calibration solutions. Replace calibration solutions at least annually. If you notice crystallization around the lid of the solutions, it's time to replace them. Your test results are only as good as the solutions that you use to calibrate your meter.

Application of injected nutrients

The potassium / nitrogen (K/N) ratio deserves careful consideration. Tomato plants require substantial nitrogen available to rapidly grow a strong plant. Nitrogen demands change during the plants lifespan. Prior to flowering, dry matter tissue levels of 5-6% N are recommended. At flowering and during subsequent fruit fill, the ratio between K and N becomes critical. Experiments in Southwest Michigan indicate that a 2K to 1N ratio is necessary to produce quality fruit during fruit filling. This ratio will tend to enhance fruit firmness as well as reduce yellow shoulder. Potassium plays a key role in water relations and epidermis (skin) elasticity. Sites that are very poor in fertility may benefit from a 3K to 1N ratio. While tissue N levels of up to 6% are advisable as plants are growing out from a transplant, those levels need to be brought down to 3.5-4.5% once fruit set and maturation get underway or suffer the likelihood of soft fruit and yellow shoulder.

The Michigan research also indicated that a single foliar application of boron at .25 lb/A reduced shoulder checking. In some, but not all cases foliar calcium applied both with and without boron was also beneficial. Growers need to be cautious in applying micronutrients such as boron as excessive amounts can result in fruit defects and phytotoxic damage to skin and leaves.

Once tomato plants are fruiting look for the following tissue nutrient levels (by dry matter):

Nitrogen	N	3.5-4%
Phosphorus	P	.8-1%
Potassium	K	3+%
Calcium	Ca	2.5-3%
Magnesium	Mg	.5-.9%
Sulfur	S	.3-1.2%
Manganese	Mn	40-500ppm
Zinc	Zn	20-50ppm
Boron	B	25-75ppm
Copper	Cu	5-20ppm

A good program to begin injecting nutrients is to base your initial applications on general plant population requirements. An acre of tomatoes needs approximately #.5 of N per day. From this starting point, you can adjust your program as necessary based on soil and tissue analysis. A tomato acre has 4,840 plants (plants 18" apart with rows on 6' centers). Start with a balanced fertilizer such as 20-20-20 (1-1-1 ratio) or 20-10-20 until the first flowers appear, Switch to a high K, low N fertilizer at this point such as 9-15-30 1-1.5-3 or 4 ratio) and adjust other nutrients based on tissue results. There is good research to support moving to a high potassium program two weeks prior to flowering as this is when the higher consumption begins. This may explain why growers that begin to increase potassium at flowering or shortly after find it so difficult to restore plant tissue levels.

Calcium is a little special as it does not move from older plant leaves, so plants need it regularly for reduced cracking, firmness and preventing blossom end rot. Tissue testing will reveal whether you need to adjust this nutrient. It is not uncommon to have to regularly tweak levels of Mg and Ca. Note that testing for tissue Ca and Mg is always measuring past uptake. However, measuring these levels is useful in adjusting your regular feeding program.

Foliarly Applied Nutrients

Keeping up with rapidly ripening fruit demands when a single tomato plant may be ripening #8-15 of fruit at a time requires careful attention. High yielding tomato varieties often benefit from the application of very small amounts of Ca, Mg, B, and K to foliage. Research has demonstrated a synergy between the application of potassium to the roots coupled with a foliar application of potassium. Regular applications of Ca, Mg and K help in maintaining sufficient levels of these nutrients during highest demand. Carefully follow the label directions and double check your math as there is always the potential to burn leaves and fruit through wrongly applied foliar materials. Avoiding applications during the hottest part of the day once temperatures reach 85F will greatly reduce the potential for these phytotoxic reactions from spray materials. Materials that are blended specifically for foliar application have adjuvants that increase the uptake of nutrients through leaf tissue.

Some relatively new information

-Tissue phosphorus level drop shortly after fruit set is an annual event. Start tissue testing about 4 weeks after planting, then continue every 2 weeks until last fruit set. In field research, tunnel tomatoes consistently go through a deep P drop in plant tissue that have required adding a high P soluble to the mix (12-48-8 in our case, but there are other similar materials) for several weeks. After 2-3 weeks of this high P regimen we go back to regular maintenance fertilizers such as 9-15-30 or 8-16-42.

-When to switch from a balanced to a high K soluble? Earlier wisdom was that we switched at the onset of blossoms. One of the reasons catching up is always so difficult is that we've been starting several weeks late. High potassium usage begins several weeks before flowering. This earlier potassium need just underscores the need for a consistent tissue testing program.

-Boron everywhere: more and more fertilizers contain boron as it is often identified as being deficient. Carefully consider which fertilizers you choose, so as to avoid a boron toxicity.

-Magnesium formulation matters a great deal. While Epsom Salts / Magnesium Sulfate / $MgSO_4$ is an excellent source of Mg when building soil fertility, it is generally too slowly available to plants to provide necessary Mg when dealing with an in-season deficiency. Look for chelates, oxides, citrates and perhaps nitrates applied both foliarly (at very low concentrates) and fertigated when correcting a deficiency.

VINE CROP NUTRITION – ONE PLAN DOES NOT FIT ALL!

Tim Elkner
Extension Educator, Penn State Extension, Lancaster County

Proper nutrition is critical in the production of any crop. Low levels of available nutrients limit growth and yield while excessive levels can cause excessive growth or even toxicity. Vine crops have similar but not the same nutrient needs. By maintaining optimal nutrient levels during all stages of your vine crop growth and fruit production cycle you will maximize returns while controlling production costs.

I suggest that you start planning your vine crop nutrition program by purchasing - and reading - a copy of the current Mid-Atlantic Commercial Vegetable Production Recommendations Guide. Attend grower meetings like this as well as local dealer and Extension-sponsored meetings and get to know other growers and commercial suppliers as well as your Extension local agent. Plan to attend summer on-site meetings when offered to further increase your knowledge of fertility management.

The next important step in planning your fertility program is to take a soil test(s). Vine crops will grow poorly in soil that is not at the correct pH or is low in fertility. Both fertility and pH are most easily corrected before the crop is planted, although some fertilizer can be added during crop production. Crops growing in soil with the correct pH and fertility are prepared to produce the greatest amount of fruit which then will maximize your profitability.

While pumpkins and gourds can possibly be produced with a single pre-plant fertilizer application, all other vine crops are best managed by regular applications of fertilizer through a drip system. Be sure that you are familiar with the irrigation system you install as well as fertilizer combinations to avoid because of precipitation issues. A water test can help you understand any limitations or problems that might be caused by the chemical conditions in your water (hardness). Consult your irrigations system supplier as well as your fertilizer source for this important information.

Accurate fertilizer applications are dependent upon your understanding of your drip system. How large of an area are you actually fertilizing? How long does it take to distribute fertilizer from the site of injection to the ends of the furthest rows in the field? You will need this information when calculating the amount of fertilizer needed per application as well as how long the system needs to run to properly distribute the fertilizer.

The two main nutrients we add during the growing season to vine crops are nitrogen and potassium. While other nutrients may be added depending upon needs, your nutrition program will focus on these two elements in equal amounts. Weekly fertilizer application programs for cucumber, muskmelon and watermelon are the most refined and can be found in the Vegetable Production Guide. The amount of each nutrient applied during the season will vary with your soil type with higher amounts applied to lighter (sandier, low organic matter) soils and lesser amounts applied to heavy (silt/clay, high organic matter).

Regardless of your soil type, you should regularly evaluate the nutrient status of your vine crops with tissue tests. I advise new growers to test every two weeks and keep careful notes of fertilizer applied and nutrient status of their crops. In this way a grower can begin to get a ‘feel’ for the needs of the crop as well as response to applied nutrients. Regular nutrient monitoring will also enable a grower to see any nutrient deficiencies that may be developing in a vine crop, particularly micronutrient issues. This will enable timely corrective actions and hopefully no loss in crop production potential.

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

Some basic crop nitrogen needs for irrigated vine crops are as follows:
(note – the actual rate needed is dependent upon soil type and organic matter content)

Cucumbers – 80-150 lbs./acre
Muskmelons – 75-150 lbs./acre
Pumpkins – 50-100 lbs./acre
Winter Squash – 50-100 lbs./acre
Summer Squash – 75-100 lbs./acre
Watermelon 125-150 lbs./acre

For all vine crops it is very important that you do not apply excessive amounts of nitrogen to the crop, particularly early in development and through fruit set. Excessive nitrogen will cause vigorous vines and fruit abortion which will delay fruit set and may reduce total yields if the crop does not set until late in the season. The only remedy for high nitrogen is to let the crop grow-out of the condition so careful monitoring of nitrogen applications and tissue content is important for new growers to avoid this situation.

If you grow pumpkins or winter squash using the no-till system, your nitrogen requirements are a little higher than above. An early season nitrogen application is generally made to the cover crop to help in the production of a high amount of residue (and is not accounted for in the above recommendations). In addition, I find that an additional 10-15 lbs./acre of nitrogen is needed to maintain optimum N levels during the growing season to balance the N that is most likely tied-up in the decomposing cover crop residue. Again – tissue testing will help determine the need on your farm in your pumpkin crop.

MULCHING TO MAXIMIZE PRODUCTION

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Mulching can have many benefits for vegetable and small fruit production- from reducing disease, conserving moisture, managing weeds, hastening time to harvest, and increasing yield and quality. Choosing the right mulch can depend on the size of your operation, the crops you grow, and the benefits you most wish to derive from the mulch.

Mulches fall into two main categories- synthetic and organic mulches. **Synthetic mulches** encompass polyethylene mulches and landscape fabric.

Polyethylene (PE) mulch is widely utilized in vegetable production, due to its relatively low cost and ease of laying with a mulch layer (Fig. 1). Within in PE mulches, while all of them help conserve moisture and manage weeds within the row, there are many colors to choose from and each has their own added benefits.

- Black plastic is the most commonly used and helps with soil warming in the spring. Soil under black plastic can be 5 °F warmer than bareground. This can allow for earlier planting and, thereby, earlier harvest.
- White or white-on-black plastic is used in the summer months for its soil cooling, where soil can be a few degrees cooler than bareground.
- Silver mulch is reflective and can be used to repel thrips as a strategy to manage Tomato Spotted Wilt Virus (TSWV). It is also known to repel aphids, whiteflies, and cucumber beetles. Some studies have shown that yields can be even higher with silver mulch than black mulch.

Figure 1. Plastic mulch layer.

- Clear mulch is more effective in warming the soil than black mulch; however, it does not control weeds as well, and can act as a weed ‘greenhouse’ underneath the plastic.
- Infrared transmitting (IRT) mulches come in brown or green. They combine the heat absorbing properties of clear mulch with the weed controlling properties of clear mulch. Be sure to look for the IRT designation, as not all brown and green mulches are IRT.
- Red mulch has been used by tomato growers, as studies have shown higher yields in some cases.

With any of these mulches, cost and availability differs. You must decide if the benefit to your operation warrants the cost of the mulch.

Landscape fabric (LF) is becoming more and more popular, especially for small, diversified operations (< 5 acres) because it covers the soil both in- and between rows, effectively managing weeds. Since LFs are woven fabric, they also

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Figure 2. Landscape fabric with 1-ft lines in pink and holes burned every 3-ft in-row for squash planting.

allow for water infiltration and drip tape can be put on top of the mulch for ease of repairing leaks. Another advantage of LF is that it can be reused for 10-15 years with proper care, which can compensate for the higher initial cost. LF comes in a variety of thicknesses, widths, and lengths with lines woven in another color that are a foot apart (Fig. 2) for ease of spacing and planting. The LF can be laid out by hand by two people, preferably on a non-windy day, and should be staked down with landscape staples to prevent fabric from blowing up and/or away. Once laid, holes can be burned in fabric with a propane torch on a template (Fig. 3), which is time consuming the first year, but rolls can be marked with their spacing for ease of use (i.e., onion roll, tomato roll, etc.) in subsequent years. At the end of the season, be sure all staples are removed from the soil to prevent damage to equipment.

Figure 3. Burning holes in fabric with propane torch for crop spacing.

Biodegradable mulches are another option that fall between the synthetic and organic options, depending on the product and its ingredients. These mulches look and can be laid like polyethylene mulches but are tilled into the soil at the end of the season and will biodegrade over time. Another summary entitled Breaking Down Biodegradable Plastics goes into much greater detail on this type of mulch.

Organic mulches provide many of the benefits as synthetic mulches, such as conserving moisture, managing weeds, cooling, or warming soil (depending on season), as well as improving soil structure, reducing compaction, and adding nutrients back to the soil. These mulches can encompass many materials including straw or hay, wood chips, leaves, pine needles, and cellulose or kraft paper. On a small scale, any of these can be used depending on what is locally available and plentiful. However, on a larger scale, we most commonly see straw or hay and kraft paper being used, so we will focus on those.

Straw or hay is a great option for mulching garlic in the fall to provide added warmth throughout the winter or many other crops in spring to provide a cooling effect (Fig. 4). If using either of these, here are some important things to consider:

1) Know your source! Be sure no clopyralid or aminopyralid herbicides were used to produce the straw or hay. These herbicides are very persistent and will still be active in the straw or hay that you put in your field. They can kill or stunt many vegetable crops. Moreover, if you are a certified organic producer, this can jeopardize your certification.

2) Make sure the straw or hay is 'clean' as either of these can be a source of new weed seeds. Mulches should help with weeds, not add to them!

Figure 4. Straw mulch for melons.

3) Don't skimp! If using hay or straw, put down a thick layer (4-6 inches). The goal is to block the light from reaching the soil to prevent weeds from germinating. Trying to weed through mulch can be worse than having no mulch at all.

4) Both hay and straw provide habitat for rodents, which can lead to lots of tunneling in the field as well as holes in drip tape. Have a rodent management plan in place.

Figure 5. Pepper on cellulose mulch.

Cellulose or kraft paper can be another good option, as it can be laid with a mulch layer, fully biodegrades in the soil, is organically approved by the USDA NOP, provides a cooling effect to the soil, and can help manage weeds (Fig. 5). We found that cellulose can control weeds during the 'critical period' or first 4-6 weeks while the crop is becoming established for vining crops, like pumpkin. After that, the vine does a good job of shading out weeds. Also, cellulose is effective for nutsedge control, as the growing point of nutsedge cannot breakthrough the paper due to its thickness. However, in crops where the canopy does not fully close, weeds can become an issue later in the season. While kraft paper fully degrades, sometimes this happens too quickly, depending on weather conditions and exposure to UV light. Also, the thickness/weight is a disadvantage of this type of mulch, as shipping can be as expensive as the product itself, if you do not have a local supplier.

There are many mulching options to consider. Whatever mulch you choose, be sure it makes sense for your production system and your bottom-line.

SPIRAL PATH FARM: HOW WE MANAGE WEEDS

Will Brownback
Spiral Path Farm, Loysville, PA

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

Will Brownback is an organic produce farmer with a passion for the connection between soil and human health.

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.

ORGANIC BEEKEEPING BASICS

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Colony management is critical for the health and productivity of your honey bees. As a beekeeper, you have the privilege and responsibility for ethically managing your colonies so they can thrive. There are diverse responses to the various pest, parasite, and pathogen issues that may arise, so deciding how to respond takes education and training. The use of synthetic chemicals is common among beekeepers, but resistance to these treatments occurs relatively quickly, rendering the treatment useless, and residues of these chemicals are readily found in the wax of treat-ed colonies. A better approach is to use organic* management practices that avoid synthetic chemicals and employ integrated pest management (IPM) techniques. Beekeeping IPM involves the combination of cultural, mechanical, and chemical controls (see https://extension.psu.edu/methods-to-control-varroa-mites-an-integrated-pest-management-approach). Cultural and mechanical controls are effective at delaying chemical treatments, but most colonies require some chemical intervention each year. IPM practices call for using treatments only when a problem reaches a threshold, so regular monitoring is required. In addition, chemical treatments are strategically used in rotation to avoid resistance development.

*Due to land-use restrictions in the area around your hives, you are not likely to be able to make USDA Certified Organic honey bee products in the United States; see the "Formal Recommendation by the National Organic Standards Board (NOSB) to the National Organic Program (NOP)" for details at https://www.ams.usda.gov/sites/default/files/media/NOP%20Livestock%20Final%20Rec%20Apiculture.pdf.

Practices and Treatments Allowed in an Organic Management System

Equipment

- Traditional Langstroth or nontraditional woodenware
- Standard or small-cell foundation
- Wax or plastic foundation or no foundation
- Solid or screen bottom board
- Wooden or cloth inner cover

Feeding

- Sucrose (syrup, dry, candy board)
- Invert syrup
- Honey (as long as you trust the source)

Dr. Robyn Underwood was born and raised in Pennsylvania. She studied Entomology and Applied Ecology for her BSc from the University of Delaware, Newark, DE, where she fell in love with honey bees and beekeeping while taking a course in Apidology with Dewey Caron. She went on to study honey bees further by researching the use of formic acid to control parasitic mites in colonies kept indoors for the winter at the University of Manitoba in Winnipeg, Manitoba, Canada, where she obtained her PhD. She returned to PA and continued conducting applied research while working as an Assistant Professor of Biology at Kutztown University, and later as an Assistant Research Professor at Penn State University, University Park, PA. Her research and extension work has allowed her to interact with the large network of beekeepers from across the commonwealth, as stakeholders, advisors, and students. Robyn is very excited to have joined Penn State Extension in 2022, where she continues to engage with the beekeepers in PA and beyond while conducting applied research.

Varroa Mite Mitigation

Monitoring the mite population is critical for success. We recommend an alcohol wash for determining the mite load in each colony (see https://extension.psu.edu/alcohol-wash-for-varroa-mite-monitoring). Cultural and mechanical controls are used as measures to reduce the population of varroa mites. However, monitoring is necessary to determine when and if chemical treatments are necessary.

Cultural Controls

- Mite-resistant or tolerant stock
- Small-cell comb
- Brood break

Mechanical Controls

- Drone brood removal
- Screened bottom board
- Powdered sugar

Chemical Controls

- Hop beta acids
- Formic acid
- Oxalic acid
- Thymol

LEARNINGS FROM THE RODALE VEGETABLE SYSTEMS TRIAL

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Introduction:
Healthy soil is the foundation for healthy food and healthy people. Understanding the factors and the processes that support soil health and crop nutrient density is imperative to vegetable growers' decision making to implement management practices and cropping systems that lead to profitable, environmentally sound, and nutrient dense vegetables.

Repetitive and intensive tillage is commonly used in vegetable production to establish vegetable seed/transplant beds. This practice has its pros and cons. The pros include green manuring of the soil by turning under the cover crop and starting the seasonal crop production on weed-free, smooth soil surface beds with or without plastic mulch to seed or transplant. However, these pros come at a cost, because implementing multiple tillage practices throughout the growing season and over multiple years to control weeds will lower soil health by increasing bulkiness, stability, and nutrient cycling. These cons in return will reduce nutrient density in crops and lower resilience to changes in climate.

There is a plethora of published research data related to the impact of cropping systems and management practices on grains in long-term trials. However, there is lack of information on the impact of management practices on soil health and vegetable nutrient density in long-term vegetable cropping systems. Rodale Institute realized the need to address the concerns presented by vegetable growers on soil management to sustain productivity and crop quality in Pennsylvania. The Vegetable Systems Trial (VST), a long-term trial at Rodale Institute, is well setup trial to link soil health to vegetable nutrient density and human health.

Soil sampling and assessments:
Soil samples collected in VST from 0-10, 10-20 and 20-30 cm in 2019 were assessed for physical, chemical, and biological properties. These include bulk density, aggregate stability, mineral nutrients, microbial communities, and their abundance.

Mycorrhizal root colonization:
A study was conducted in 2021 to assess the addition of exogenous arbuscular mycorrhizal fungi on sweet corn and squash on percent root colonization. Root samples were collected just before harvest and assessed under the microscope after being cleaned for the presence and absence of mycorrhizal fungi structures.

Nutrient Quality:
Vegetable crops in VST from 2020 and 2021 were freeze-dried and ground. Subsamples were assessed for mineral nutrient concentration, vitamins, and proteins. The nutrient quality index (NQI) per each nutrient was calculated based on daily nutrient requirement and caloric needs for adults. The NQIs for potato and winter squash from VST were determined.

Dr. Gladis Zinati, Director of the Vegetable Systems Trial at Rodale Institute, is a Soil Scientist and Horticulturist with 32 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.

Major findings:

- Soil bulk density in plots with reduced tillage was lower than those managed with intensive tillage, especially in winter squash plots. Low soil bulk density is an indicator of oxygen availability to plant roots and soil microbial organisms and is better for water infiltration.
- Another soil health indicator represented by wet aggregate stability proved to be very low irrespective of the management practice. This finding indicates that disturbing the soil by implementing intensive tillage in an organic system over the past 20 years and before establishment of VST has led to low aggregate stability. Low wet aggregate stability in soil reduces the resistance to water and wind erosion, water infiltration, pore space for air and water movement and deep rooting and minimizes soil microbial habitat. Managing soil with minimal disturbance enhances resilience of soil on the long run.
- Organic system resulted in enhanced mycorrhizal fungi root colonization in squash and corn compared to the conventional system.
- Tillage without plastic reduced mycorrhizal fungi root colonization of sweet corn compared to roll-crimped management.
- Tillage increased the availability of nitrogen to plants whereas reduced tillage increased phosphorus availability to plants.
- Microbial communities varied with depth and cropping systems.
- The abundance of oxidizing ammonium archaeal was greater than the oxidizing ammonium bacteria, which is an indicator of nutrient cycling. These two microbial indicators were also greater in the organic system than in the conventional.
- Nutrient quality index (NQI) varied with crops. While Lehigh potato NQIs were affected by the cropping system, winter squash nutrients were impacted by the cropping system and management practices. Lehigh potato was nutrient dense in all measured nutrients except in calcium and iron, whereas winter squash was nutrient dense in most measured nutrients except in iron.
- Including a diverse diet that includes potato and winter squash will provide nutrient dense diet for human consumers.

In the coming years, monitoring the changes in soil bulk density and aggregate stability in addition to other chemical and biological indicators in the soil profile of the VST will validate the impact of management practices in organic and conventional systems and provide guidance to vegetable growers on implementations of optimal practices and systems to enhance soil resilience to changes in climate and vegetable nutrient density.

TARPING FOR MANAGING WEEDS

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Abstract

The application of reusable tarps as a soil preparation tool is becoming increasingly popular among small scale farms in the Northeast. Black silage tarps, clear plastic, landscape fabric, and even used billboard tarps are all being deployed to achieve a host of benefits. Weed management is the most notable and commonly desired goal with this practice, however, research and grower experience have demonstrated that crop residue decomposition, cover crop termination, soil moisture retention, exclusion of excessive rainfall, and nutrient (specifically nitrate) retention are all benefits of this practice. Surveyed farmers who use tarps stated that the leading goals of tarping were to reduce tillage and improve soils, allow early spring access, to hold fields weed free until planting, and to create stale seed beds (Rangarajan, 2019).

Application of tarps as a pre-planting practice to control weeds can be successful in less than one week during the peak day length and warmth of the season, but three weeks or more during shoulder seasons. Tarps can also be deployed over winter to reduce spring labor requirements and to provide good weed suppression for early crops. Tarping is being used on farms with many different approaches to tillage, including full width tillage, in rotational no-till systems, or even continuous organic no-till systems. Tarps are also being used to convert perennial sod ground into vegetable production fields.

While tarping has many advantages, there are some tradeoffs that perspective users should be aware of. The amount of time that the tarps need to be in the field means that those beds are out of crop production for that amount of time. Handling tarps can be labor intensive which limits the scale that they can be used on. Farmers involved in our work are on 5 acres or less, but mostly under 3 acres. While tarping is an effective tool to manage most types of weeds, there are several weed species that are not controlled with tarps, especially under short duration applications. This can lead to the requirement for alternative management strategies and increased populations of those more problematic species.

Despite those concerns, tarps are helping farms to successfully reduce labor requirements for weed management, to reduce tillage and equipment use, and to enhance soil and crop quality. This talk will cover the most recent data and producer experiences. The Northeast IPM Center hosted publication, *Tarping in the Northeast: A Guide for Small Farms* is a comprehensive publication on the topic for further reading.

Overview

Tarping is an increasingly popular practice for managing soils on small farms. Tarping can be categorized into 2 categories of **solarization**, or **occultation**. Solarization is the utilization of solar energy to create high temperatures under clear plastic tarps. Occultation is the practice of using opaque tarps, often black, to exclude light to emerging weeds, thereby killing them. Both approaches change light, temperature, and moisture dynamics at the surface level.

Solarization works by increasing the temperature at the soil surface. This practice is most effective during the long day lengths around the summer solstice through mid-summer. Solarization and can be successful with about 2 weeks of duration. To achieve the high temperatures required for weed management, the tarp edges must be buried to hold

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heat in. If done effectively, temperatures have been recorded to reach 115º. If air is allowed to enter under the tarp, temperatures will not reach high enough levels and weeds can grow rapidly in the protected warm environment. Intact, used greenhouse plastic can be used for solarization.

Due to the limitations of the time of year (peak summer) and required precise management of the tarp edges to achieve success with solarization, occultation with black tarps is much more widely used. Black tarps can be secured with many commonly available materials including sandbags, concrete blocks, or by burying edges. Soil temperatures under black tarps commonly reach no more than 10º higher than bare soil temperatures. While this may have some effect on increasing weed seed germination rate, the temperatures are not high enough to kill weeds. Occultation systems are thought to kill emerging weeds through the exclusion of light.

A diversity of tarp types may be used for occultation. The most used tarp type is the polyethylene silage tarps that are 5 to 6 mil thick. These tarps are commonly available in a wide variety of sizes and are cost effective. Polypropylene woven landscape fabric is another option. This material allows water to penetrate which may or may not be desirable. Temperatures are lower under landscape fabric; however, the light exclusion provides adequate weed suppression. Polyvinyl chloride (PVC) used billboard tarps are another option. These 6 to 10 mil thick recycled tarps are heavy, giving them a longer life and helping them to stay in place well. However, they are generally only available in smaller dimensions. certified organic producers cannot use these tarps as they are not allowable under National Organic Program (NOP) rules. Tarps can be ordered or cut to a variety of sizes. Standardizing plot sizes significantly simplifies tarp use. It is important to balance tarp weight with the time needed to secure edges. Be sure to account for extra width if using tarps on raised beds, due to tarps settling into the wheel tracks.

Soil moisture is key for success with tarping. If the soil is very dry when tarps are applied, weed seeds will not germinate, leading to poor results. Some farms will apply overhead irrigation prior to tarping to ensure adequate moisture prior to tarping all plots. Some producers are also using tarps to exclude excessive water if a heavy rain event is predicted. While this is helpful for mid plot conditions, it can compound field (tarp) edge soil moisture. Moving tarps with water on them can also be difficult due to the extra weight.

When pulling tarps back, it is common to see dead white thread stage weeds that have apparently died due to heat or a lack of light. The increased temperatures under the tarp, increase the rate of germination of these seeds, which are then killed due to unfavorable conditions. If the soil is left undisturbed except for transplanting or direct seeding crops after the tarps are removed, the weed pressure in those beds can be remarkably low. This is particularly effective for most annual weed species. However, nearly 10% of farmers using tarps reported that some weeds had become bigger problems since they began tarping (Rangarajan, 2019). Perennial weed species with below ground energy reserves, and certain annual weed species are not controlled with this practice. Purslane (Portulaca oleracea L.) is one annual weed species that is unfazed by tarping. Crabgrass (Digitaria spp) appears to be condition dependent, being controlled on some farms, but increasing in abundance on others, including in my garden! Due to the lack of competition after tarping, the escaped weed species can become dominant. Close observation, and backup weed management strategies are key.

While some farms are tilling prior to tarping to prepare the soil, others are utilizing tarps to move away from tillage. Some examples of these systems include greens producers who apply fertility and compost, and till the soils once in the springtime, and then deploy the tarps. After the required tarping duration, the farmer rolls back the tarp on as many beds are required for that succession, while leaving the tarp on the rest of the bed. After harvest, another tarp is applied to the spent bed, killing and breaking down the remaining crop residue. After one to two weeks of mid-season tarping, the tarp is removed, and another succession is direct seeded into the bed. This results in the requirement for only one tillage pass per season.

Heavy cover crop residue no-till systems involve the planting of a thick winter rye, or winter rye and hairy vetch fall prior to the planting season. When the rye cover crop reaches anthesis in late May or early June, the cover crop is knocked down with a roller or disengaged rototiller, just to get it laying down in one direction. Tarps are applied at that point to both kill the cover crop, and any weed seeds under the cover crop. After two weeks of tarping, crops can either be transplanted into the residue, or a zone tillage implement can be used to rip a strip through the residue in the planting rows. This system only works with light texture soils or soils that have had significant organic matter additions. Heavy soils can become compacted under the tarps, making transplanting very difficult, and limiting crop growth.

Deep mulch tarping systems involve amending the soils with significant amounts of organic amendments, most commonly compost. This is an involved system that is designed to bury native soils and weed seed banks. Tarps are often key component to these systems to suppress any weed seeds that are brought to the surface or blown in, to break down crop residue, and to terminate cover crops. This system is very expensive to initiate with some producers bringing in the equivalent of 200 yards of compost per acre. However, the system has the potential to significantly increase the crop productivity per area, and to decrease labor needs of weed management once the system is established. Users of this system need to keep a close eye on nutrient levels as that amount of compost will result in very high nutrient levels.

There are many applications for tarps in small scale farming operations. Find out more about the logistics of using tarps and read case studies of farmers varied uses of tarps at The Northeast IPM Center hosted publication, Tarping in the Northeast: A Guide for Small Farms.

Lounsbury, N., Birthisel, S., Lilley, J., Maher, R. 2022. Tarping in the Northeast: A Guide for Small Farms. UMaine Extension Bulletin. https://extension.umaine.edu/publications/1075e/

MENDING THE STRESS FENCE

Cynthia Pollich MS Ed.
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Agriculture ranks among one of the most stressful and hazardous industries. Farmers face numerous risks, including personal injuries, extreme and unpredictable weather conditions, machine breakdowns and rollovers, disease outbreaks in their herds or flocks, and fluctuating crop prices. Managing these challenges can create undue stress on the farmer and farm family.

Mending the Stress Fence was developed by Michigan State University Extension in response to the increasing stress levels in the farming community.

In this workshop, you will learn about:

- The signs and symptoms of stress in agriculture
- The Eight Dimensions of Wellness
- How to ask open-ended questions
- The warning signs of suicide
- Access to resources to help support someone in need

The Penn State Extension Farm Stress team, comprised of educators from multiple disciplines, understands and supports the farming community.

In addition to the **Mending the Stress Fence** webinar, our team offers:

Virtual webinars and in-person workshops are available upon request.

- **Communicating with Farmers Under Stress,** a workshop designed for individuals in the community, agriculture industry professionals, veterinarians, loan officers, family members, and others who regularly interact with farmers. This 2-hour workshop provides an overview of the stressors experienced by farmers and their families, strategies for responding, and best practices to connect those affected with local, state, and national resources.

- **Weathering the Storm in Agriculture: How to Cultivate a Productive Mindset,** another 2-hour workshop to help farmers and farm families understand the effects of stress on the mind and body and how to manage it effectively during difficult times.

The Farm Stress team encourages anyone who wants to know more about mental wellness, reducing the stigma of mental health and substance use challenges, and how to approach and assist someone with a mental health challenge to attend the **Mental Health First Aid** webinar through Penn State Extension. This 8-hour evidence-based webinar was created by the National Council for Mental Wellbeing and or **QPR**. Developed by the QPR Institute, this two-hour training is designed for all people, regardless of their background, who are concerned about helping others with mental health and substance use challenges.

Cynthia Pollich is an Extension Associate in Family Wellbeing (FWB) at Penn State Extension Lancaster PA where she is the Co-Director of the FWB team. She delivers evidence-based classes related to Mental Wellness/ Mental Health, Financial Literacy, Early Childhood and parenting, Kinship care and more. She has her M. S. Degree from The City University of New York, Queens College in Early Childhood with a minor in science. She has been with Penn State for 30 years. She is originally from Queens, New York, she, and her husband John have three adopted children, Karl, Erik and Samantha.

BEST OF THE PENN STATE FLOWER TRIALS 2022

Sinclair Adam
Penn State Extension, Lebanon County

2022 was a hotter and drier year at the PSU Flower Trials. Temperatures were in the 90-degree range for a greater number of days than in 2021. Rainfall was less than in previous years in August. Close to 1000 cultivars were tested in 2022 from 32 companies including firms from the USA, Germany, The Netherlands, Israel, Thailand, the Czech Republic, and Japan. More Begonias were in the program in 2022 (81) and 89 petunias. Generally, plants did well in 2022. Two collaborative sites are maintained at Hershey Gardens (Hershey, PA) and North Park (Allegheny County PA).

Angelonia 10 cultivars

Best Performance:
- AngelDance Fuchsia Bicolor-Ball FloraPlant
- AngelDance Violet Bicolor-Ball FloraPlant
- AngelMist Spreading Dark Purple Imp. -Ball FloraPlant
- Archangel Purple Imp. -Ball FloraPlant
- Archangel Raspberry-Ball FloraPlant
- Archangel Blue Bicolor-Ball FloraPlant
- Archangel White-Ball FloraPlant
- Aria Alta Pink-Dummen Orange

Begonia 83 cultivars

Best Performance:
- BIG Red Bronze Leaf-Benary
- Double Up Red-Proven Winners
- Hula Spreading Bicolor Red White-PanAmerican Seed
- Hula Spreading Red-PanAmerican Seed
- Jurassic Pink Splash-Ball Ingenuity
- Dreams Garden MacaRose-Beekenkamp
- Dreams Garden MacaRouge-Beekenkamp
- I'Conia Lemon Berry-Dummen Orange
- Surefire Rose-Proven Winners
- BK Collection Vermillion Hot Pink-Beekenkamp
- I'Conia Scentiment Peachy Keen-Dummen Orange
- Megawatt Pink Green Leaf-PanAmerican Seed
- Tophat Pink-Syngenta Flowers
- BIG Deep Rose Bronze Leaf-Benary
- BK Collection Frivola Pink-Beekenkamp

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, & Pi Alpha XI.

	Jurassic Green Streak-Ball Ingenuity
	Beauvilia Dark Salmon-Beekenkamp
	BK Collection Bonny-Beekenkamp
	Bowler Bronze Leaf White-Syngenta Flowers
	Surefire Red-Proven Winners
	Jurassic Jr. Arctic Twist-Ball Ingenuity
	Jurassic Pink Shades-Ball Ingenuity
	BK Collection Vermillion Red-Beekenkamp
	Double Up White-Proven Winners
	Hula Spreading Pink-PanAmerican Seed
	Megawatt Pink Bronze Leaf-PanAmerican Seed
	Viking Explorer Rose on Green-Sakata Seed America
	Jurassic Jr. Berry Swirl-Ball Ingenuity
	Orange Lantern-Selecta One
	Beauvilia Red-Beekenkamp
	BIG Red Green Leaf-Benary
	Bionic Green Leaf Pink-Syngenta Flowers
	BK Collection Rhodee Pink-Beekenkamp
	Dragon Wing Pink-PanAmerican Seed
	Dragon Wing Red-PanAmerican Seed
	Tophat Scarlet-Syngenta Flowers
	Tophat White-Syngenta Flowers
	Viking Explorer Red on Green-Sakata Seed America

Bidens 6 cultivars

Best performance:	Namid Compact Yellow 23-Selecta One
	Namid Red + Yellow Eye-Selecta One

Bracteantha 4 cultivars

Best Performance:	Granvia Gold-Suntory Flowers

Caladium 5 cultivars

Best Performance:	Crystal Moon-Classic Caladiums
	Proven Winners Heart to Heart Snow Flurry-Proven Winners
	Proven Winners Heart to Heart Lemon Blush-Proven Winners

Calibrachoa 56 cultivars

Best Performance:	Bumble Bee Blue-Ball FloraPlant
	Cabaret Yellow-Ball FloraPlant
	Pocket Red-Kientzler North America
	Pocket White-Kientzler North America
	Conga Yellow-Ball FloraPlant
	Pocket Blue-Kientzler North America
	Pocket Dark Pink-Kientzler North America
	Superbells Coral Sun-Proven Winners
	Cabaret Diva Pink-Ball FloraPlant
	Cha-Cha Yellow-Ball FloraPlant
	Superbells Yellow 2023-Proven Winners
	Cabaret Hot Rose-Ball FloraPlant
	Cabaret Midnight Kiss-Ball FloraPlant

Conga Purple Star-Ball FloraPlant
Cha-Cha Diva Apricot-Ball FloraPlant

Cha-Cha Frosty Lemon-Ball FloraPlant
Conga Pink Kiss-Ball FloraPlant
Cha-Cha Diva Hot Pink-Ball FloraPlant
Cha-Cha Fuchsia-Ball FloraPlant
Cha-Cha Red-Ball FloraPlant
Conga Rose Imp. -Ball FloraPlant
Superbells Prism Pink Lemonade-Proven Winners
Superbells Dbl. Yellow-Proven Winners
Superbells Dbl. Twilight-Proven Winners
MiniFamous Uno Dbl. White-Selecta One

Celosia 18 cultivars
Best Performance: Flamma Golden-Sakata Seed America
Bright Sparks Bright Yellow-Syngenta Flowers
Kelos Fire Lime-Beekenkamp
Flamma Red-Sakata Seed America
Flamma Orange-Sakata Seed America
Flamma Rose-Sakata Seed America
Kelos Atomic CESP 2081 Purple-Beekenkamp
Kelos Atomic Violet-Beekenkamp
Kelos Fire Orange-Beekenkamp
Kelos Candela Pink-Beekenkamp
Kelos Fire Magenta-Beekenkamp
Kelos Fire Red-Beekenkamp
Bright Sparks Burgundy-Syngenta Flowers
Kelos Fire Scarlet-Beekenkamp
Kelos Atomic Neon Pink-Beekenkamp

Coleus & Plectranthus 21 cultivars
Best Performance: Dragon Heart-Ball FloraPlant
Main Street Yonge Street-Dummen Orange
Peach Frizzle-Ball FloraPlant
Stained Glassworks Pineapple Express-Dummen Orange
Trailblazer Glory Road-Ball FloraPlant
ColorBlaze Pineapple Brandy-Proven Winners
ColorBlaze Mini Me Watermelon-Proven Winners

Combinations 56 cultivars
Best Performance: MixMasters Conga Line-Ball FloraPlant
MixMasters Amped Up-Ball FloraPlant
MixMasters Powers That Bee-Ball FloraPlant
Trixi On The Double 23-Selecta One
MixMasters Fire & Spice-Ball FloraPlant
Confetti Garden Clockworks-Dummen Orange
Confetti Garden Endurable Beauty-Dummen Orange
Confetti Garden Summer Sunset-Dummen Orange

		MixMasters Berrytones-Ball FloraPlant
		MixMasters Hot Spell-Ball FloraPlant
		SunPatiens Mix White Wedding-Sakata Seed America
		Confetti Garden Rainbow Bridge-Dummen Orange
		Trixi Enchanted Evening-Selecta One
		MixMasters Bloomin' Glory-Ball FloraPlant
		MixMasters Glimerazzi-Ball FloraPlant
		SuperCal Premium Mix Orange Popper-Sakata Seed America
Cyperus 3 cultivars		
	Best Performance:	Graceful Grasses Queen Tut-Proven Winners
		Baby Moses-Kientzler North America
		Graceful Grasses Prince Tut-Proven Winners
Dahlia 27 cultivars		
	Best Performance:	Venti Mango-Selecta One
		LaBella Grande Dark Pink-Beekenkamp
		LaBella Maggiore Deep Rose-Beekenkamp
		LaBella Gigante Fun Pink-Beekenkamp
Evolvulus 1 cultivar		Beach Bum Blue-Dummen Orange
Geranium 5 cultivars		
	Best Performance:	Falcon F1 Salmon-Cerny Seed
		Falcon F1 Violet-Cerny Seed
Gomphrena 2 cultivars		
	Best Performance:	Truffula Pink-Proven Winners
Helianthus 2 cultivars		
	Best Performance:	Suncredible Yellow-Proven Winners
Heliotropium 2 cultivars		
	Best Performance:	Hinto Amethyst-Dummen Orange
		Augusta Lavender-Proven Winners
Homalocladium 1 cultivar		Ribbons and Curls-Kientzler North America
Impatiens hybrida 17 cultivars		
	Best Performance:	SunPatiens Compact Classic White-Sakata Seed America
		SunPatiens Compact Lavender Splash-Sakata Seed America
		Solarscape Magenta Bliss-PanAmerican Seed
		Spectra White-Syngenta Flowers
		Solarscape Neon Purple-PanAmerican Seed
		SunPatiens Compact Lilac Imp.-Sakata Seed America
		Spectra Pink-Syngenta Flowers
		SunPatiens Compact Purple Candy-Sakata Seed America
		SunPatiens Vigorous Pretty Pink-Sakata Seed America
		SunPatiens Vigorous White Imp.-Sakata Seed America
		Solarscape XL Salmon Glow-PanAmerican Seed
		Spectra Magenta-Syngenta Flowers

Spectra Orange-Syngenta Flowers
SunPatiens Vigorous Red-Sakata Seed America

Impatiens NGI 22 cultivars
Best Performance: ColorPower Orange 23-Selecta One
Magnifico Star Pink-Benary Plus
Magnifico Hot Pink-Benary Plus
Rokoko Orange-Kientzler North America
Paradise Orange-Kientzler North America
Cabano White-Kientzler North America
Magnifico Orange-Benary Plus
SunStanding Flame Orange-Dummen Orange

Impatiens walleriana 27 cultivars
Best Performance: Lollipop Raspberry Imp.-Benary
Beacon Lindau Mix-PanAmerican Seed
Beacon Portland Mix-PanAmerican Seed
Imara XDR Orange Imp.-Syngenta Flowers
Imara XDR Tango Mix-Syngenta Flowers
Imara XDR Red Star-Syngenta Flowers
Lollipop Coconut Imp.-Benary
Beacon Sanibel Mix-PanAmerican Seed
Imara XDR Hot! Mix-Syngenta Flowers
Imara XDR Mix-Syngenta Flowers
Imara XDR Red Imp.-Syngenta Flowers

Ipomoea 4 cultivars
Best Performance: Sweet Caroline Medusa Green-Proven Winners
Sweet Caroline Upside Black Coffee-Proven Winners
Sweet Caroline Upside Key Lime-Proven Winners
Illusion Penny Lace-Proven Winners

Juncus 2 cultivars Blue Mohawk-Proven Winners
Graceful Grasses Curly Wurly-Proven Winners

Lantana 27 cultivars
Best Performance: SunDance Pink-Sakata Seed America
Bandolista Pineapple-Syngenta Flowers
Bandolista Red Chili-Syngenta Flowers
Luscious Royale Lemon Tart-Proven Winners
Hot Blooded Red-Syngenta Flowers
Bandolista Mango-Syngenta Flowers
Luscious Basket Tangelo-Proven Winners
Bandana Gold-Syngenta Flowers
Bandolista Coconut-Syngenta Flowers
Gem Diva Pink-Danziger Flower Farm
Heartland Blue Moon-Dummen Orange
Shamrock Butterscotch Glow-Ball FloraPlant

	Gem Gold-Danziger Flower Farm Havana Yellow-Dummen Orange Shamrock Peach Imp.-Ball FloraPlant
Lavender 1 cultivar	LaVela Compact Dark Pink 23-Selecta One
Marigold 6 cultivars	
Best Performance:	Endurance Yellow-Syngenta Flowers Endurance Sunset Gold-Syngenta Flowers
Muehlenbeckia 1 cultivar	Big Leaf-Proven Winners
Nemesia 2 cultivars	
Best Performance:	Aromance Pink-Proven Winners
Osteospermum 8 cultivars	
Best Performance:	Sunny OST 0002 Purple-Beekenkamp Voltage Gold-Ball FloraPlant Bright Lights Horizon Sunset-Proven Winners
Pentas 5 cultivars	
Best Performance:	Graffiti 20/20 Appleblossom-Benary Starcluster Cascade Blush-Syngenta Flowers Starcluster Cascade Pink Bicolor-Syngenta Flowers Starcluster Cascade Red-Syngenta Flowers
Petunia 89 cultivars	
Best Performance:	Itsy Magenta-Syngenta Flowers Supertunia Mini Vista Yellow-Proven Winners Bees Knees-Ball FloraPlant Supertunia Mini Vista Hot Pink-Proven Winners Fun House Peach Melba-Syngenta Flowers Supertunia Mini Vista Pink Star-Proven Winners Itsy White- Syngenta Flowers Supertunia Mini Vista Midnight-Proven Winners ColorRush White-Ball FloraPlant Shortcake Raspberry-Syngenta Flowers Surfina Heavenly Cabernet-Suntory Flowers Tea PTTR 0041 Flamingo- Beekenkamp Tea Rose Morn-Beekenkamp Cascadias Rim Cherry IMP.-Danziger Flower Farm ColorRush Pink-Ball FloraPlant Headliner Blackberry Vein-Selecta One Main Stage White 22-Selecta One SureShot White-Ball FloraPlant ColorRush Purple-Ball FloraPlant Red Carpet RIMarkable-Danziger Flower Farm Supertunia Mini Vista White-Proven Winners Supertunia Vista Jazzberry-Proven Winners F1 Trilogy Salmon Morn-American Takii

Fun House Amethyst Sunshine-Syngenta Flowers
Kuyamba White-Kientzler North America
Shortcake Blueberry-Syngenta Flowers
Cascadias Fuchsia-Danziger Flower Farm

Cannonball Coral-Ball FloraPlant
ColorRush Blue-Ball FloraPlant
ColorRush Merlot Star IMP.-Ball FloraPlant
Main Stage Glacier Sky-Selecta One
SureShot Blueberries & Cream-Ball FloraPlant
Tea Magenta Vein-Beekenkamp
Tea Purple-Beekenkamp

Portulaca 8 cultivars
Best Performance: Mojave Yellow 2023-Proven Winners
Mega Pazzaz Gold-Danziger Flower Farm
Mega Pazzaz Red-Danziger Flower Farm
Mega Pazzaz Purple-Danziger Flower Farm

Ptilotus 1 cultivar Matilda-Benary

Rudbeckia 10 cultivars
Best Performance: Sunbeckia Carla-Bull Genetics
Sunbeckia Sarah-Bull Genetics
Sunbeckia Maya-Bull Genetics
Sunbeckia Lucia-Bull Genetics
Sunbeckia Laura-Bull Genetics
Sunbeckia Mia-Bull Genetics

Salvia 13 cultivars
Best Performance: Blue Chill-Ball FloraPlant
Unplugged Pink-Proven Winners
Purple & Bloom-Ball FloraPlant
Sallyfun Pure White-Danziger Flower Farm
Sallyfun XL Blue-Danziger Flower Farm
Sallyfun Blue Lagoon-Danziger Flower Farm

Scaevola 6 cultivars
Best Performance: Surdiva White Improved-Suntory Flowers
Surdiva Purple-Suntory Flowers
Fairy Pink 23-Selecta One

Sedum 3 cultivars
Best Performance: Coral Reef-Selecta One
Little Shimmer-Selecta One
Little Shine-Selecta One

Verbena 27 cultivars
Best Performance: EnduraScape Blue-Ball FloraPlant
Lascar Mango Orange-Selecta One
Lascar Orange Lava-Selecta One

Lascar Blue + White-Selecta One
Vanessa Compact Neon Pink-Danziger Flower Farm
EnduraScape Pink Bicolor-Ball FloraPlant
EnduraScape Magenta-Ball FloraPlant
EnduraScape Red-Ball FloraPlant
Lascar Purple + White-Selecta One
Vanessa Compact Bordeaux-Danziger Flower Farm

Vinca 16 cultivars
Best Performance:
Volcano F1 Apricot-Cerny Seed
Volcano F1 Burgundy-Cerny Seed
Volcano F1 Lavender-Cerny Seed
Volcano F1 Red-Cerny Seed
Mega Flow Dark Red-AmeriSeed
Volcano F1 Orchid-Cerny Seed
Volcano F1 Peach-Cerny Seed
Soiree Double White-Suntory Flowers
Cora Cascade White IMP-Syngenta Flowers
Mega Bloom Vivid Violet-AmeriSeed
Volcano F1 Polka-Cerny Seed
Soiree Flamenco Cheeky Pink-Suntory Flowers
Volcano F1 White-Cerny Seed

Zinnia 7 cultivars
Best Performance:
Holi White IMP. AmeriSeed
Zesty Yellow-PanAmerican Seed
Zydeco Deep Yellow-Syngenta Flowers

Zinnia Double 6 cultivars
Best Performance:
Double Profusion Fire IMP.-Sakata Seed America
Belize Double White-American Takii
Belize Double Scarlet-American Taki
Belize Double Yellow-American Takii
Belize Double Orange-American Takii
Belize Double Rose-American Takii

DAMPING OFF AND ROOT ROT MANAGEMENT

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Damping off.
Damping-off is an old-fashioned sounding disease, but it still happens today. This is the term used for plants being killed before they get well started in life. They may either be killed before they make it out of the ground (or out of the mix) or afterwards, and these two phenomena are called "pre-emergence damping off" and "post-emergence damping off". In pre-emergence damping-off, infected seeds may swell with water and rot or seeds may put out a root that is quickly rotted off. In post-emergence damping off, both roots and shoots are initiated, but after the new seedling is visible above-ground, it suddenly withers and collapses because of fungal attack underground or at the soil line. Roughly 30 different fungi are known to be capable of damping-off. Among these, the most notorious are species of *Pythium, Rhizoctonia, Fusarium, Botrytis and Alternaria*, but other fungi can cause damping-off as well. Often the damping-off fungi travel as contaminants of seed, but they may alternatively be introduced to the growing crop because it becomes contaminated with field soil. This is why the best bedding plant operations are impeccably clean.

Having clean seed and a growing mix that has been kept free from contamination with field soil are the secrets to avoiding damping-off. For this reason, re-using plug trays without thoroughly disinfesting them is a dangerous practice. Many of the damping-off pathogens make resistant survival structures called sclerotia or chlamydospores, which can linger within organic debris that still clings to flats a year after a previous disease outbreak. The oospores of *Pythium, Phytophthora* or downy mildews are primarily for sexual reproduction, but they also allow long-term survival in plant debris. Removing it is essential to avoid cycles of disease being repeated every year.

In addition to sanitation practices, fungicides can be an aid to damping off management. The trick is to supply a broad spectrum of control. Use both an ingredient that control *Pythium* (and other oomycetes) as well as one that controls true fungi. This can be achieved by the use of pre-mixes e.g. Banrot (thiophanate-methyl plus etridiazole or Hurricane (mefenoxam + fludioxonil) or by making your own tank mix to cover the possibilities ranging from Rhizoctonia to Pythium. The crops you grow and their particular disease sensitivities will determine which benches need fungicide treatment and what fungicides should be used. If you have excellent sanitation practices, you will be able to scout instead of treat, and only need resort to spot applications of fungicides when you detect a disease outbreak.

Root Rots.
Root rots are usually caused by some of the same pathogens that cause damping-off. A few additional organisms become important on the older plants, notably *Phytophthora* (an oomycete) and *Berkeleyomyces* - previously *Thielaviopsis* (a fungus).

<u>*Pythium.*</u> Various *Pythium* and *Globisporangium* species (*Globisporangium ultimum* and *G. irregulare*, for example) are the most general problems for crops grown in flats or containers. If the mix does not drain well, or is overwatered, Pythium root rot is especially favored. Its life cycle as an oomycete, or water mold, is inextricably tied to water. When

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roots are infected, plants are stunted, and quality is reduced. Looking from aboveground, plants may be shorter, with smaller leaves and premature, stunted flowers. They may also be killed outright. The roots are attacked in the region of elongation near the tip, and the cortex of the root is rotted when the fungi act as parasites of the plant cells. This gives the roots an off-color: they become grayish or tan and watersoaked rather than a healthy white. The outer cortex of the root can easily be slipped off the inner vascular core because it has been partially digested by the fungus. By knocking plants out of their pots and looking at roots directly, you will see the off color and the water-soaking, especially in roots at the bottom of the container. Very few fungicides work strongly against Pythium: some of the most reliable include cyazofamid and etridiazole. It will be important to use fungicides in rotation, especially if you are using mefenoxam, because some strains of Pythium are resistant to that chemistry.

Phytophthora. Another oomycete, a relative of the Pythium and *Globisporangium* species, Phytophthora is seen less often and is more likely a problem on one crop at a time. Under warm, humid conditions, *Phytophthora nicotianae* is guilty of attacks on vinca, African violet, peperomia, petunias and poinsettias as well as a number of other plants. It tends to cause soft, wet-looking, brown or black cankers at the soil line, but can also affect roots and branches. Fortunately there are more fungicides effective against *Phytophthora* than there are for *Pythium*. *Strobilurins*, for example, help a great deal with Phytophthora management but not with Pythium management. *Biofungicides* and cultural controls, on the other hand, are more likely to help significantly against Pythium than against *Phytophthora*.

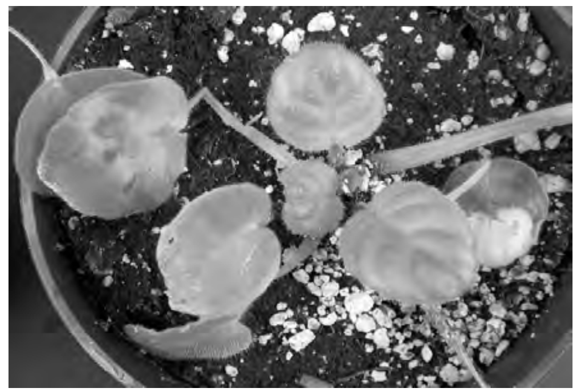
Rhizoctonia. The fungus *Rhizoctonia solani* has a very broad taste for bedding plants. It specializes in post-emergence damping-off, constricting and browning tiny stems at the soil line. On older plants it will cause brown cankers at the soil line, sometimes completely girdling and killing the stem. It is favored by high humidity and thus is in its element during vegetative propagation under mist, blighting leaves as well as stems. Certain Rhizoctonia fungi act as web blights, moving up the stem and onto the leaves, killing interior foliage: we've seen this on chrysanthemum in recent years, and it also is common on azaleas. In the past *Rhizoctonia* was often introduced on seed but in modern greenhouse culture it is more likely introduced on the plant material or by accidentally bringing in soil to the growing area. When flats are stored they should be encased in plastic so that particles of soil aren't blown onto them. And a shoe-sole cleaning station will help to prevent tracking soil-borne fungi such as Rhizoctonia into the greenhouse. Hose ends dropped to the floor of the greenhouse and then used for watering are another avoidable way that fungi can get into the crop area, as are mulching materials that might be contaminated with field soil. Biofungicides containing *Trichoderma* or *Bacillus* species or thiophanate-methyl drenches provide some protection against Rhizoctonia root and stem diseases. Chemical materials with the best effectiveness include azoxystrobin, fludioxonil, and triflumizole.

Berkeleyomyces. The fungus *Berkeleyomyces basicola*, once called Thielaviopsis, is the agent of black root rot. It will be a particular problem for growers whose growing mix has a high pH—a pH of 6.2 and above very much favors this root rot pathogen. Affected plants grow unevenly: they are stunted, and the foliage often takes on a yellow or purple discoloration. Below ground, the root system is also stunted; plants may show a dark brown or black root rot. With a microscope, resting spores of the fungus are visible and allow a definite identification. Black root rot is common on particular crops, rather than being a general problem. In particular, watch for it on calibrachoas and petunias, violas and pansies, as well as vincas of all types and poinsettias. This fungus has spores that efficiently allow it to survive from year to year, so it is especially dangerous to reuse flats or pots after a crop has succumbed to this disease. If containers are reused, the organic debris should first be removed with strong jets of water and then surfaces should be properly disinfested—or at the least the contaminated containers should be used for a crop that is not prone to black root rot.

Fusarium. *Fusarium* species as root rotters are often found right along with *Pythium* species. They are favored by high levels of ammonium nitrogen in the soil, and by wet conditions in the growing medium. The most damaging of the *Fusarium* species cause more than simple root rot: crops including cyclamen and chrysanthemum also have the possibility of vascular wilt diseases caused by specific, host-adapted strains of *Fusarium oxysporum*. These fungi invade the vascular system of the entire plant by way of the roots, leading to stunting and wilting of portions of plants, or entire plants. Fungicides and bioantagonists (*Bacillus*, *Trichoderma*, and *Streptomyces* spp.) help against Fusarium, but will not give 100% control, so rely on exclusion as much as possible.

Managing the Major Root Pathogens of Greenhouse Flower Crops		
Root Pathogen	**Tips**	**Labeled FRAC Groups**
Berkeleyomyces [black root rot]	Keep pH below 6.0, control fungus gnats, use a well-drained growing medium, inspect plug roots on receipt.	1, 3, 12, 19
Fusarium	Use calcium nitrate feed, avoid excess soil moisture. Trichoderma biofungicides help to suppress.	1, 2, 11, 12
Pythium	Avoid over-fertilization; use a well-drained growing medium. Use biofungicides preventively.	4, 11, 14, 21, 33, 43
Phytophthora	Avoid excess wetness. Scout crops that are prone to this. Rogue out symptomatic plants and treat the rest.	4, 11, 14, 21, 33, 40, 43, U15
Rhizoctonia	Keep field soil out of greenhouse. Use biofungicides preventively.	1, 2, 3, 7, 11, 12, 19

Damping-off by Rhizoctonia solani has caused this patch of collapsed celosia seedlings.



Water-soaked petioles and leaf base browning from Phytophthora nicotianae infection of African violet.

Rhizoctonia solani blighting leaves of New Guinea impatiens during propagation.

Black root rot on Catharanthus roseus causing severe stunting on plant at left.

Rhizoctonia solani blighting leaves of New Guinea impatiens during propagation.

Fusarium root and crown rot on hosta.

Browned, water-soaked roots on a mum wilting from Pythium root rot.

MANAGING TOUGH INSECTS AND MITES WITH BIOPESTICIDES

Steve Bogash, Territory Business Manager, ProFarm Group

Our rapidly expanding toolbox of biopesticides now provides growers with effective products to manage even our most challenging insects such as Western Flower Thrips (WFT). Proactive growers that pay careful attention to fine details can effectively manage greenhouse pests using a biologically-based insecticide program. Most of these biological pesticide products have broad enough labels to allow them to be used on most greenhouse-grown plants and are effective on a broad swath of pests.

Biopesticides have unique modes of action (MOA) that can provide levels of pest management often not possible with synthetic products alone, and can often be used either in programs or tank mixes to manage resistance or simply layer MOA's in order for an application to last longer or provide a broader pest control range. However, they are different enough from conventional pesticides that their application requires strict adherence to the labeled application instructions. Often pH, tank mixing, and surfactant instructions are very precise in order to reach maximum efficacy.

Biopesticide products to manage insect and mites

-Grandevo® WDG and CG (Chromobacterium Subtsugae strain PRAA4-1-T): Provides insect and mite management primarily through, gut disruption with some repellancy.. While slow to kill pests, feeding ceases rapidly, so the damage stops quickly. Good rotation partner with Venerate (below) and azadirachtin materials. Best efficacy is with a pH neutral spreader – sticker. Compatible with many beneficial insects (BCA's).

-Venerate™ CG and XC (Burkholderia spp. strain A396: Primary MOA is as a gut disruptor. Best efficacy is with a pH neutral spreader – sticker. Good rotation partner with Grandevo. Compatible with most beneficial insects (BCA's).

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

-MET-52®, (Metarhizium anisopliae strain F52). Very similar to B. bassiani products in this products MOA. It is part of a growing group of fungal insecticides. Non-selective, so not for use with BCA's.

-Ancora® and PFR-97®, (Isaria fumosorosea). Very similar to B. bassiani products in this products MOA. It is part of a growing group of fungal insecticides. Non-selective, so not for use with BCA's.

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

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

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. In 2022, Marrone Bio became the Pro Farm Group Inc. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

-Insecticidal soaps. There are many of these potassium salts-based soaps on the market. They make excellent tank partners with many of the products noted above. Like oils, they can cause phytotoxic damage. Therefore, avoid using at high rates, in short rotations or on sensitive crops. These soaps have that added benefit of acting a spreading agent.

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

REALLY TOUGH PERENNIALS IN THE PENN STATE FLOWER TRIALS

Sinclair Adam
Penn State Extension, Lebanon County

Perennials are tested for three years at the Penn State Southeast Agricultural Research and Extension Center in Manheim, PA. Winters fluctuate in temperature from single digits (degrees F) to 45-50 degrees F over a season. These temperature fluctuations create a challenge for perennial entries. Plants are protected from deer injury by deer fencing from fall to spring. Top performing perennials presented are good survivors that perform well over 2-3 seasons. Irrigation is provided as needed.

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 Sunnyside	Dummen Orange
12.	Coreopsis Fall Sensation Amber	Dummen Orange
13.	Delphinium Desante Blue	KieftSeed
14.	Delphinium Delgenius	Pacific Plug and Liner
15.	Dianthus Mountain Frost Ruby Snow	Darwin Perennials
16.	Dianthus Mountain Frost Red Garnet	Darwin Perennials
17.	Dianthus Mountain Frost Rose Bouquet	Darwin Perennials
18.	Echinacea Cara Mia	Terra Nova Nurseries
19.	Echinacea Kismet White	Terra Nova Nurseries
20.	Echinacea Lovely Lolly	Must Have Perennials
21.	Echinacea Sombrero Poco Yellow	Darwin Perennials
22.	Echinacea Moodz Dream	HilverdaFlorist
23.	Echinacea Green Twister	Jelitto Perennial Seeds
24.	Eupatorium Euphoria	Darwin Perennials
25.	Fern Athyrium niponicum pictum Godzilla Painted Fern	Casa Flora
26.	Fern Athyrium niponicum pictum Japanese Painted Fern Regal Red	Casa Flora

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, & Pi Alpha XI.

27.	Fern Athyrium niponicum pictum Pearly White Painted Fern	Casa Flora
28.	Fern Dryopteris pulcherrima Beautiful Wood Fern	Casa Flora
29.	Gaillardia SpinTop Mariachi Copper Sun	Dummen Orange
30.	Gaillardia Heat It Up Yellow	Proven Winners
31.	Geum Tempo Yellow	Terra Nova Nurseries
32.	Helenium Bandera	Plants Nouveau
33.	Helenium Salsa	Plants Nouveau
34.	Heliopsis Sole Scuro	Kientzler North America
35.	Heliopsis Summer Eclipse	Darwin Perennials
36.	Helianthus Suncatcher	Kientzler North America
37.	Helleborus Ice & Roses Red	Skagit Horticulture
38.	Heuchera Black Forest Cake	Terra Nova Nurseries
39.	Heuchera Ruby Tuesday	Terra Nova Nurseries
40.	Heuchera Dolce Wildberry	Walters Gardens Inc.
41.	Heuchera Grande Black	Terra Nova Nurseries
42.	XHeucherella Peach Tea	Terra Nova Nurseries
43.	Hibiscus Summerific Evening Rose	Walters. Gardens Inc.
44.	Hibiscus Summer Spice Plum Flambe	J. Berry Nursery
45.	Leucanthemum Rebecca	Dummen Orange
46.	Leucanthemum Amazing Daisies Collection Proven Winners Banana Cream II	Walters Gardens Inc.
47.	Nepeta Blue Prelude	Darwin Perennials
48.	Nepeta Cat's Pajamas	Walters Gardens Inc.
49.	OG Pennisetum Yellow Ribbons	Intrinsic Perennial Gardens
50.	OG Pennisetum Love and Rockets	Intrinsic Perennial Gardens
51.	OG Pennisetum Pure Energy	Intrinsic Perennial Gardens
52.	Rudbeckia American Goldrush	Intrinsic Perennial Gardens
53.	Rudbeckia Glitters Like Gold	Intrinsic Perennial Gardens
54.	Salvia Midnight Rose	Dummen Orange
55.	Salvia Midnight Purple	Dummen Orange

CREATING A NETWORK OF CUT FLOWER GROWERS IN MAINE

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Abstract

The number of farms producing cut flowers and cut florist greens in Maine rose from 183 in 2012 to 256 in 2017 (NASS, 2017). At that time, there was very little acknowledgement of or support for the industry among agricultural service provider agencies (i.e. Cooperative Extension, Maine Organic Farmer and Gardener Association, Department of Agriculture Conservation and Forestry, Maine Farmland Trust, etc.). Producers were mostly gaining professional development and technical support from the decentralized Association of Specialty Cut Flower Growers. While this association is a great resource for producers, many growers wanted more localized support. A small group of experienced flower growers approached their local Extension Educator to express this need, ultimately convincing him of the need for a local conference.

Staff at the UMaine Cooperative Extension office in Cumberland County organized a planning committee of farmers and developed the 1st *Flowering in the North conference* in 2018. This 2-day program sold out at 100 participants within 3 weeks of registration opening. Participants were from as far away as Iowa, New Jersey, Ontario, and Nova Scotia. In 2019, the team found a larger space and sold out a pre-conference design track at 50 people, and the 2-day program with 200 participants. Participant evaluations highlighted an excitement to have a space to learn from peers, both informally during networking opportunities and from presentations. In 2020, the program adjusted to a retreat intensive, where producers spent 2.5 days assessing the state of the industry and developing the foundation for the Maine Flower Collective, a project currently being launched to create a collaborative marketing cooperative to give Maine cut flower producers access to more diverse market opportunities.

Keywords: *Cut Flowers, Grower Cooperative, Farmer to Farmer, Peer Networks*

Introduction

At an Organic vegetable production conference in the winter of 2017, experienced cut flower farmers from 3 neighboring farms approached their local Extension educator about the lack of educational opportunities for cut flower farmers in the Northeast. They proposed the creation of a conference specific to cut flower production and offered to sit on the planning and advisory committee to help pull this off. A budget was created that included compensation for the advisory committee and the majority of the speakers (mostly farm operators), in addition to the typical conference expenditures. In January of 2018 we held a very successful Flowering in the North program in Portland, ME with three concurrent tracks. The program included a networking session and floral design demonstration. Program evaluations revealed that the most commonly noted "most valuable parts of the conference" were 1) "The conversations between everyone", 2) "Getting to ask questions informally during and after presentations", and 3) "Meeting other flower farmers". This demonstrated to our team the importance of creating this educational opportunity, but also of being intentional to create networking opportunities for future programs.

In preparation for a 2019 program the committee realized that we needed a larger space to accommodate more people, and more networking opportunities. The team decided to move the conference location to the larger University of Southern Maine campus, and to add a pre-conference track. That track was open to 50 individuals and led by a well-known floral designer from New York City, and the flower farmer partner who she sourced most of her blooms from. This was a full-day hands-on program where participants got to work with a large diversity of products. The

Jason Lilley is a graduate assistant with the Department of Plant Science at the Pennsylvania State University. There he has focused his thesis research on field preparation techniques and row cover use for cucurbit production. He has his B.S. degree in Horticulture from Delaware Valley College. He formally worked as an agriculture extension volunteer with the U.S. Peace Corps promoting conservation tillage practices, cover crop use, and school gardens. Jason is from Houlton, ME.

full conference sold out at 200 participants and included 3 simultaneous tracks, and a keynote speaker. The program was a success, but a lot of work for the entire planning committee.

For the Winter of 2020, the committee decided to move the conference to an every other year program, with something requiring lower effort to be offered in the off years. It's very debatable as to whether hosting a retreat requires less effort than a conference, but that was the choice. Interested attendees were required to fill out an application. The review committee was looking for a diversity of producers with more than 3 years of experience to be part of this retreat to the North Maine Woods. 30 participants were invited to this off-grid winter adventure at an Appalachian Mountain Club operated facility for 2.5 days of discussion and peer-learning. The purpose of the retreat was to dive into the state of the industry, and to apply holistic management principles to ownership and management of a cut flower farm. The Flowering in the North leadership team facilitated discussions on;

- Strengths, Weaknesses, Opportunities, and Challenges (SWOC) analysis of individual businesses
- SWOC of the Industry
- Clarifying individual values and goals
- Prioritizing areas of improvement and investment personally and of the industry
- Financial planning approaches
- And Work life balance and holistic approaches to business ownership

Post retreat evaluations stated that 50% of respondents (n=13) planned to implement new financial management approaches, while 31% planned to implement self-care practices such as setting time away from the farm or setting an owner draw amount. Another major take-away from this retreat was the cut flower industry in Maine would benefit greatly from collaborative marketing, and easier access to markets in Portland, Boston and beyond.

Due to the pandemic the 2021, and 2022 programs were virtual with highly interactive breakout groups on topics including production, pandemic adjustments and financial programs, mental health, and diversity, equity, and inclusion.

During this time, a team of producers formed to apply for a State of Maine Specialty Crop Block Grant. They were awarded $90,200 for "The Formation of a Maine Flower Collective: A cooperative to enhance the competitiveness and market research of Maine's cut flowers." The funding supported this team in launching the Maine Flower Collective "MFC" in 2022. They hosted the Maine Flower Collective Convergence in the Fall of 2022. The objective of the MFC fall convergence was to assemble a cohort of specialty cut flower farmers, florists and floral designers from Maine and nearby states to discuss the formation of a cooperative that will be known as the Maine Flower Collective. Additional funding will be necessary to begin to implement the strategic plan for the MFC.

Farmers are extremely busy individuals. They frequently drop hints, or bluntly request a nudge to encourage them to leave the farm to network with other farmers, or to step way back and have clearer visioned opportunity to reflect. The creation of the Maine Flower Collective demonstrates to me the role of agricultural service providers to create these spaces for growers to step back, learn from each other, and develop goals for how to move forward individually, or in cohorts. These opportunities can be key for growers to improve their emotional, financial, production, and industry wide health.

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IDENTIFYING CUT FLOWER GROWER NEEDS: HOW COOPERATIVE EXTENSION IS WORKING TO SERVE THE INDUSTRY

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The wholesale value of cut flower sales increased 1.5 times from 2020 to 2021 (2021-2022 New York State Agricultural Statistics Bulletin) for operations of $100,000 or more. This is clearly an underestimate of the total cut flower production in the state because so many of our operations are small and not counted in the survey. Anecdotally, growers come from a wide variety of backgrounds, often not agricultural. While Chris Wien, at Cornell, did cut flower research from 2004 until 2015, there has not been any University based research done on cut flowers since then. At about the same time, cut flower growers in the Capital District started asking Lily Calderwood, the Regional Commercial Horticulture Educator, for help and in 2016 she organized the first Annual Cut Flower Conference, held in Albany. That conference has been held ever since, through 3 educators and a pandemic-necessitated switch to a virtual format.

However, based on the questions that several Cornell Cooperative Extension (CCE) educators were getting, there was a need for additional information and programming to support the growing cut flower industry. The result was a loosely organized program team that grew – and continues to grow - somewhat organically from grower input to programming and presentation of information.

1. Co-teaching of an on-line course

Lindsey Christianson, the second Regional Commercial Horticulture Educator for the Capital District, and I had started a conversation on the lack of resources for local cut flower growers on production and pest management. In 2021, the Cornell Small Farms program asked her to teach a beginning cut flower course, based on several years of requests for such a class and as the only Extension educator in the system working with growers. As she was leaving for a graduate program, she suggested me. I have co-taught BF 170 Cut Flower Production with Hannah Volpi, Foxiflora – a cut flower grower in Trumansburg, NY – for two years now – with over 150 registrants from the US and beyond. It is a 6 week, on-line class, with live recorded sessions on a teaching platform that includes slides and recordings of each session, a student forum with leading questions, and a page for additional resources. Hannah covers production and I cover pest management.

2. Development of an educator committee

Another suggestion from Lindsey led to a conversation between Dana Havas, CCE Cortland, and me. This resulted in a state-wide request for other educators to meet for a discussion of what the cut flower production issues were as reported through Extension. Twenty-five educators met on May 18, 2022 and discussed their own needs and those of growers:

Elizabeth Lamb is the Coordinator for Ornamental IPM for the New York State Integrated Pest Management Program. As such, she works with greenhouse, nursery and Christmas tree growers to find effective methods of managing insect, disease, weed and mammal pests. She was previously employed by the University of Florida and the University of Arkansas in their Horticulture programs. She has a PhD in Plant Breeding from the University of Minnesota and also attended Cornell University and Smith College. She is from Geneva NY and currently lives in Ithaca NY with an office at Cornell University.

Grower needs	Educator needs
Weed management	Information on speakers, topics, and resources
Planting schedules	Information on industry – crops, marketing methods, production methods, research
Marketing and determining profitability	Networking
Use of high tunnels	Programming needs for both new and experienced growers
Ways to engage customers	
Soil fertility	

This has led to monthly meetings and collaboration on projects such as a webinar series on risk management for cut flower growers and the joint submission of a grant.

3. Creation of a listserv and a webpage for information exchange

The major source of information on cut flower production in NYS is the growers themselves so an interactive listserv was created in 2021 for questions and answers, announcements of events, and sharing of resources. A group on educators and growers were recruited as members to provide a base of knowledge. There are currently 175 members, up 49% from 2021. Postings are still sporadic, as people have time and find it useful. A webpage (https://blogs.cornell.edu/cutflowers/) was created and made public in Fall 2022 to archive resources, including listserv threads. It is still 'under. construction' in some respects, as we build out the resources and make it useful to growers. Like any webpage, it needs advertising and substance to drive traffic.

4. Expanded collaboration and programming

Programming for cut flower growers has increased dramatically in the last 2 years, and based on committee discussions, will continue to grow and add topics in the future.

Program	Description	Region
2022 Annual Cut Flower Conference	4 sessions, 8 speakers – crops and varieties; nutrients and soils; business and farm resiliency	Online, Jingjing Yin, Capital District CCE
2022 Empire State Producers Virtual Expo - Cut flower session	Marketing, soil building, disease management	Online, Elizabeth Lamb
2022 Summer and Fall Field Days on Soil Health for Cut Flower Growers	On-farm field based programs capped at 25 (8/2/22) and 45 (10/18/22) attendees	Capital Region, Jingjing Yin
2022/3 Risk Management for Cut Flower Growers	IPM; Crop planning Soil Health, Irrigation and Fertility; Season Extension, Wholesale buying and selling	Online and recording available, Carla Crim CCE Delaware
2023 Annual Cut Flower Conference	6 sessions – disease and insect management, biocontrol, high tunnels, variety selection, marketing	Online, Jingjing Yin

WEED CONTROL OPTIONS FOR CUT FLOWERS

Alan Leslie, Univ. of Maryland

Herbicide options for cut flowers are generally very limited. The high diversity of flower species and varieties grown in relatively small spaces makes it difficult to find chemicals labelled for use across entire fields. Additionally, research and industry support specific to cut flower production is generally lacking, and as a result growers find themselves somewhere in the middle between having cultural practices similar to annual vegetable production and a crop list similar to ornamental landscape plantings. Below we outline some of the herbicides that we feel are among the most useful for cut flower production, and describe their potential use in flower farming. Remember to always read and follow all label instructions when using pesticides, including wearing the proper personal protective equipment. Any mention of specific product names is for educational purposes only and is not meant as an endorsement by University of Maryland Extension.

Glyphosate (active ingredient in Roundup and many other products) is a non-selective, broad-spectrum, and systemic herbicide that is a very useful tool for vegetation management. Formulations of glyphosate are labelled for in-season use for managing weeds between crop rows using hooded or shielded sprayers to minimize the risk of drift onto desirable crop plants. However, the use of glyphosate around flower crops is not recommended because of the high risk of injury from even minimal drift. Instead, we recommend that glyphosate be used as a pre-plant burndown application to kill any emerged weeds prior to planting the flower crop. This strategy works especially well when planting directly into bare-ground without the use of plastic mulch, as glyphosate will kill all emerged weeds without having any residual effect on the cash crop. In-season use of glyphosate should be limited to spot-treatment of especially problematic weeds, under conditions where drift can be minimized.

Glufosinate (active ingredient in Interline and other formulations) is a broad spectrum alternative to glyphosate, which is much safer to use around established flower crops. Glufosinate does not have the systemic activity that glyphosate has, so although glufosinate drift may cause localized injury to crop plants, it is less likely to severely stunt or kill crop plants when used as a directed spray. There are also organic alternatives to provide complete burndown of weeds, such as d-limonene (Avenger), caprylic/capric acid (Homeplate), and acetic acid. Flaming weeds with a propane torch is another non-chemical alternative for pre-plant and row-middle weed control that would be compatible with cut flower production. The organic burndown options (including flaming) all work best on small weeds, under 3-4" in height, and all work best on broadleaf weeds as compared to grasses and sedges.

Although these options will kill all weeds within row middles, maintaining bare ground through the growing season is not necessarily recommended, as this leaves the row middles vulnerable to erosion. Many farmers using raised beds with plastic mulch will simply let the annual grasses and other weeds grow within the row middles and manage the resulting vegetation by mowing. However, planting cover crops in the row middles can reduce erosion of bare soil while reducing weed problems by seeding a small grain or annual grass forage species that will be easier to manage than the native weed community. Cover crops that we have trialed between rows of plastic include spring oats (early season), teff (mid-season), and cereal rye (fall/overwinter), however there are many other options that would work well with cut flower production.

Selective herbicides are an option for managing vegetation between crop rows in-season while maintaining soil coverage with cover crops or annual grass weeds. Clethodim (active ingredient in Select Max and other formulations) is a grass-selective herbicide that can be used to suppress grass cover crops, without the risk of killing flower crops. Clethodim can be especially useful for managing grasses directly adjacent to the shoulders of plastic mulch, where mowers may not be able to reach.

Dr. Alan Leslie got his Ph.D. from the University of Maryland studying invertebrate communities in agricultural drainage ditches on Maryland's Eastern Shore with Dr. Bill Lamp. Alan went on to work as a postdoc with Dr. Cerruti Hooks at UMD studying weed management and conservation biological control of insect pests in grain and vegetable systems. Alan is currently working as an Extension Educator in Agriculture and Food Systems with University of Maryland Extension in Charles County. His extension programming incorporates sustainable approaches to insect and weed pests in agronomic and vegetable crops.

Finally, pre-emergence herbicides are another useful tool for cut flower production, especially for perennial flower species. Pre-emergence herbicides prevent weed problems by killing weed seeds as they germinate, which makes application timing very important for pre-emergence products; they do not work if weeds have already started to grow. Early season application of products like trifluralin or S-metolachlor around established perennial plants can greatly reduce the weed pressure that these crops face during the growing season.

Figure 1. Clethodim was applied to the half of the row middle in the foreground to kill seedling grass weeds. The row middle to the left has a spring oat cover crop broadcast onto the bare ground.

As mentioned previously, the wide diversity of crop species and varieties in the cut flower trade makes it impossible to guarantee that you won't see crop injury from using these or any other products that may be labelled for use on your farm. We recommend that you test any new products over a limited area and check for crop response before applying any new herbicides over large areas, especially if the crops are actively flowering at the time of application. Additionally, many of these herbicides require surfactants or other adjuvants to maximize efficacy, which can also cause injury to crop plants, especially under hot and sunny conditions.

Preplant burndown

Glyphosate	group 9	Roundup and other brand names
1 gallon = 2 fl oz glyphosate + 2 oz ammonium sulfate		
Notes: Broad-spectrum control of weeds, systemic herbicide that will cause stunting, deformation, or death in desirable plants. No residual activity. Glyphosate is labelled for use around existing crops with shielded sprayers, however this use is not recommended because of the risk of damaging flower crops.		

Post-emergence, row middles

Glufosinate	group 10	Interline and other brand names
1 gallon = 2 fl oz glufosinate + 2 oz ammonium sulfate		
Notes: Thorough coverage is essential, ideally apply during hot, sunny conditions, do not allow to contact green tissue of desirable plants, no residual activity.		

D-limonene	group N/A	Avenger (OMRI approved)
1 gallon = 1 - 2 pt d-limonene		
Notes: Contact herbicide needs thorough coverage to kill weeds. Mostly effective on small, annual, broadleaf weeds.		

Caprylic/Capric acid	group N/A	Homeplate (OMRI approved)
1 gallon = 4 - 12 fl oz Caprylic/Capric acid		
Notes: Contact herbicide needs thorough coverage to kill weeds. Mostly effective on small, annual, broadleaf weeds. Rapidly kills weeds.		

Clethodim	group 1	Select Max and other brand names
1 gallon = 1 fl oz clethodim + 0.35 fl oz non-ionic surfactant		
Notes: Grass-selective herbicide that will not kill broadleaf weeds. Works best on small grasses that are actively growing. Slow-acting herbicide, may take up to 2 weeks to kill grass weeds. Safe to contact crop plants, though surfactant may cause injury to sensitive plant parts like flowers, especially during hot, sunny conditions.		

Pre-emergence/Residual

Trifluralin	group 3	Preen and other brand names
6 lbs trifluralin/1000 ft^2 (dry prills)		
Notes: Use around established perennial plants to prevent weeds from emerging. Spread evenly with shaker, do not over-apply around base of crop plants. Water-in to activate. Will not control weeds that have already emerged. Do not use around vegetables or other edible plants.		

S-metolachlor	group 15	Pennant Magnum & other brand names
1 gal = 0.5 - 0.75 oz *S*-metolachlor		
Notes: Do not use with direct-seeded crops, use with transplanted annuals and established perennials only. Will control a broad range of broadleaf and grass weeds, including yellow nutsedge.		

EXTENDING YOUR CUT FLOWER SEASON WITH HIGH TUNNELS

Laura Beth Resnick, Butterbee Farm

Growing cut flowers in unheated hoophouses increases the quality and reliability of the crop, and extends the flower season into those crucial shoulder holidays (Mother's Day and Thanksgiving). In this session, we cover the following topics:

Bed preparation using occultation and no-till methods
Irrigation using drip tape
Pests- aphids, caterpillars, and more
Disease- botrytis, powdery mildew, and more
Temperature management
Snow management
Salt buildup

We also cover crop planning in high tunnels. Selecting the right crops is important to make the best use of valuable high tunnel space. We discuss choosing varieties and selecting spacing so that crops are tight as possible to create a good canopy for crowding out weeds.

Laura Beth Resnick is the founder and owner of Butterbee Farm, a five acre flower farm in northern Maryland. Following regenerative practices, Butterbee Farm provides locally grown flowers to florists and flower lovers from Baltimore to Washington, D.C. Growing in greenhouses, high tunnels, and fields, Butterbee Farm specializes in high quality cuts for use in design. Laura Beth has served as President of the MCFGA (Maryland Cut Flower Growers Association) and Secretary for the Board of the ASCFG (Association of Specialty Cut Flower Growers), and continues to write for their quarterly magazine. She speaks regularly at conferences, garden clubs, and arboretums, and mentors new growers through Future Harvest's Beginning Farmer Training Program.

REVIEW OF POWDERY MILDEW MANAGEMENT

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Powdery mildew is the most common disease of cucurbit crops partly due to the quantity of wind-dispersed spores the pathogen produces and the fact it doesn't need leaves to be wet to infect as other fungal pathogens do. Management is needed to avoid reduction in yield and/or fruit quality. Powdery mildew is best managed with an integrated program including both management tools (resistant varieties and fungicides) that is based on efficacy results from research. The pathogen has demonstrated ability to evolve and become less effectively controlled by both tools, but especially conventional, targeted fungicides. An integrated program maximizes likelihood of effective control.

Guidelines on Managing Cucurbit Powdery Mildew.

1) Select resistant varieties. Resistant varieties are now available in most crop groups with new varieties released most years. Resistance in cucumber is standard in modern varieties and is so strong it is easy to forget this cucurbit type is susceptible until an Heirloom type is grown. Cantaloupe with resistance to pathogen races 1 and 2 have exhibited excellent suppression; however, this will change if a new race evolves. Resistance in other cucurbit crop types is not adequate used alone (without fungicide treatment) to prevent impact of powdery mildew on yield and fruit quality.

2) Inspect crops routinely for symptoms beginning at the start of fruit production, or start applying fungicides then. This physiological stress makes plants susceptible. It is especially important to examine the lower surface (underside) of leaves because powdery mildew develops there best. The IPM action threshold for starting a fungicide program is one leaf with symptoms out of 50 old leaves examined. It is worthwhile to assess control after about half and three quarters of the applications have been made, especially when conventional, targeted fungicides are used. Symptoms becoming severe on lower leaf surfaces is most likely because of resistance in the pathogen to the targeted fungicides applied or poor application timing. Continuing to apply targeted fungicides will likely not be worthwhile due to limited benefit. Do a final assessment of control achieved 7-10 days after last application. It is especially important to examine lower leaf surfaces when targeted fungicides are used.

3) Apply fungicides weekly starting at the IPM action threshold or onset of fruit production.

Organic fungicide program. There are many biopesticides labeled for powdery mildew. See https://www.vegetables.cornell.edu/ipm/diseases/biopesticides/. Sulfur is the most effective organic fungicide. Micronized formulation is a better choice than wettable powder. Recent research documented that sulfur (Microthiol Disperss) applied in alternation with a biopesticide was as effective as sulfur applied weekly. Copper is not as effective; it is recommended when bacterial disease is also a concern. Achieving control on the lower surface of leaves is challenging because these are all contact fungicides, and the cucurbit canopy makes it difficult to deliver spray directly to the lower surface.

Conventional fungicide program. Fungicides with targeted activity for powdery mildew have proven very important because they are able to move through leaves to the underside where the pathogen develops best, but because of their targeted mode of action they have medium to high risk for resistance to develop in the pathogen. It is very difficult to

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deliver fungicide directly to the underside of large cucurbit leaves even with air assist sprayers. Consequently, contact fungicides (sulfur, chlorothalonil, biopesticides) provide good control on the upper but not the lower leaf surface, and thus do not prevent premature leaf death due to powdery mildew. Fungicides recommended for powdery mildew routinely change as new products are registered and the pathogen often develops resistance to fungicides after they have been in use for several years. Targeted fungicides need to be used in alternation to delay development of resistance, avoid control failure when resistance develops, and comply with label use restrictions on number of consecutive and total applications allowed. Alternate among available, recommended chemistry based on FRAC code and apply with protectant fungicides. Some targeted fungicides have narrow activity (just powdery mildew) necessitating applying additional products when other diseases are occurring.

Fungicide recommendations are based on results from university research assessing product efficacy, which varies due to inherent differences in fungicide activity and can be reduced when the pathogen develops resistance, and research on resistance occurrence in the pathogen. Every year at LIHREC seedling bioassays and isolate testing have been done to determine current status of resistance and impact of fungicide programs. Through this work fungicide resistance has been confirmed in NY to FRAC 1, 3 (triadimefon; no longer labeled), 7 (boscalid), 11, 13, and U6 fungicides. Resistance likely has or could develop elsewhere. For examples, bioassays conducted in OH in 2020 revealed resistance to FRAC 7 (Pristine, Fontelis and Merivon) and U6 (Torino); Rally (3) was also ineffective. Quintec (13) was moderately effective suggesting some resistant isolates present. Vivando (50), Gatten (U13), and Procure (3) were most effective.

Alternate among targeted, mobile fungicides in the chemical groups below (first two most important), and apply with contact, protectant fungicide to manage resistance development. Begin very early in disease development (one older leaf out of 50 with symptoms).

Vivando or Prolivo (FRAC 50). Activity is limited to powdery mildew. They can be applied 3 times (4 for Prolivo at low label rate which is not recommended) with no more than 2 consecutive applications. REI is 12 and 4 hr, respectively. PHI is 0 days. Do not mix Vivando with horticultural oils. Less sensitive isolates have recently been detected. Prolivo has exhibited variable efficacy on lower leaf surfaces in university trials which could be due to whether an adjuvant as recommended by the company was used, application timing (started before or after disease onset), and conditions. Prolivo was effective when tested in 2022 at LIHREC. It was not as effective as Vivando in OH in 2021 or as Gatten in PA in 2021.

DMI fungicides (FRAC 3) include Proline, Procure, and Rhyme (these considered most effective) plus Aprovia Top, Folicur, Inspire Super, Mettle, Rally, Tebuzol, and TopGuard (also has FRAC 11 ingredient). Efficacy varies from moderate to excellent (Proline) in fungicide evaluations. Cevya is not as effective for powdery mildew on lower leaf surface as most others. Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Procure applied at its highest label rate provides a higher dose of active ingredient than the other FRAC 3 fungicides. Five applications can be made at this rate. REI is 12 hr for these fungicides. PHI is 0 to 7 days. Powdery mildew is the only labeled cucurbit disease for some of these.

Carboxamide fungicides (FRAC 7) currently recommended include Luna fungicides (Luna Experience recommended), Aprovia Top, and Miravis Prime (also has FRAC 12 ingredient which targets other diseases). REI is 12 hr. PHI is 0-7 day. Maximum number of applications is 2-5, depending on rate used. Low rate is not recommended. Powdery mildew pathogen strains resistant to boscalid, active ingredient in Endura and Pristine, have been detected since 2009 on Long Island and likely are the reason for poor efficacy in some fungicide evaluations. In laboratory assays, boscalid-resistant strains exhibited sufficient cross resistance with Fontelis and Merivon that these are expected to be ineffective as well, but not with Luna fungicides. However, Luna Sensation failed in experiment at LIHREC in 2017. Luna Experience also contains tebuconazole (FRAC 3), which needs to be considered when developing an alternation program. Luna Sensation is not recommended because it also contains trifloxystrobin (FRAC 11); resistance to this chemistry is very common. Limit use of Luna Experience as less sensitive isolates have been detected recently.

Gatten (FRAC U13) was not as effective for powdery mildew on lower leaf surfaces as Vivando when tested at LIHREC in 2018 and OH in 2021; it was moderately effective in PA.

Switch (FRAC 9+12) ingredient with activity for powdery mildew (9) has greater activity for other labeled diseases and is recommended for powdery mildew only when needed for other diseases.

Resistance is a major issue. Recent testing has revealed that most resistant isolates are resistant to up to five different fungicide chemical (FRAC) groups. Occurrence of multi-fungicide resistant isolates is a concern for successfully managing powdery mildew because it means applying any one of these fungicides to a crop can select for these multi-fungicide resistant isolates, potentially resulting in none of these fungicides being adequately effective. Resistant isolates are fully resistant (growth not reduced on fungicide-treated leaf tissue in bioassays) and they have not exhibited reduced fitness. Frequency of resistant isolates in a commercial planting can increase a lot in response to fungicide use during a growing season. This pathogen is expected to continue developing resistance to targeted fungicides.

Testing of powdery mildew pathogen isolates collected from commercial crops of pumpkin and winter squash in NY (west, east, and Long Island) at the end of the 2021 season revealed a high percentage of isolates (67-100%) being resistant to Quintec from the three crops treated twice with Quintec even though the fungicide program was good with alternation amongst targeted chemistry and all applications included a protectant fungicide. Many Quintec-resistant isolates were also resistant to Torino (FRAC U6) and Endura (7) although these or related fungicides were not applied. Almost all isolates tested were also resistant to MBC fungicides (FRAC 1; Topsin M), although now in limited use on cucurbits generally, and QoI fungicides (FRAC 11; Quadris, Cabrio and Flint). Quintec-resistant isolates were detected in only two of the nine crops where this fungicide was not applied (29 and 50% of isolates tested). Only contact fungicides were applied to one of these crops, thus there was no selection pressure in that field for resistance. Torino was applied once to the other crop, and 50% of isolates were resistant to Quintec, Torino, and Endura. These fungicides are no longer recommended based on these research results, as well as results from previous research. An application of one of these might contribute to control, but that cannot be predicted.

Additional information about powdery mildew and its management, both conventionally and organically, is posted at https://www.vegetables.cornell.edu/pest-management/disease-factsheets/ cucurbit-powdery-mildew/. There is a link to webpages with research results.

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.

BREAKING DOWN BIODEGRADABLE PLASTICS FOR YOUR PRODUCTION SYSTEM

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Plastic or polyethylene (PE) mulch has been used in vegetable production since the 1950's. We know that there are numerous benefits for many crops, such as weed control, moisture regulation, reduced disease, and higher quality and yield. However, the environmental drawbacks of PE mulch are also well established, like mulch disposal issues (Fig. 1) and plastic pollution, with reports of microplastics in our food and water supply. Biodegradable plastic mulches (BDMs) have been shown to be a viable alternative, providing similar crop yields compared to PE, with the benefit of being able to be tilled into the soil at the end of the season and breaking down into carbon dioxide, water, and microbial biomass.

Figure 1. Disposal of plastic mulch can be a challenge. Often it is piled on farm, discarded in nearby waterways, or burned.

Biodegradable mulches have the potential to be a sustainable technology if they can:

- Provide the benefits that PE mulch does
- Reduce labor costs for removal and disposal
- Decrease landfill waste
- Biodegrade completely
- Cause no harm to the soil or surrounding environment.

What should you consider when choosing a biodegradable mulch?

1) What crop(s) would you like to grow or how long you want the mulch to stay intact?
The plastic biodegradable mulches are designed to eventually breakdown. Therefore, they can be tailored to the length of time your crop is in the ground. Of course, a thinner mulch will break down more quickly and will be cheaper than a thicker mulch, so only pay for what you need. Along the same lines, these mulches behave differently in different climatic environments, so a mulch in hot, humid conditions will breakdown more quickly than a mulch in the cool dry conditions.

2) What is your main goal in using the mulch?
As mentioned above, there are many benefits of using mulch and just like with plastic mulches, BDMs can be tailored for different purposes. For instance, if early soil warming is a benefit you're after, a black mulch would be a good choice. If you require a soil cooling effect, a brown paper or white mulch would be a good choice. Furthermore, some crops, like pumpkin, benefit from weed control during the critical period or first 4-6 weeks of production, and then shade weeds out themselves once they vine. In this case, cellulose or paper mulch can

Annette Wszelaki is the Vegetable Extension Specialist at the University of Tennessee, where she has statewide responsibilities for developing a comprehensive educational program in commercial vegetable production. The main focuses of her extension program include production and variety recommendations, diversifying production, developing alternative crops, organic and sustainable production, season extension, postharvest handling, and produce safety. The goal of her program is to help growers reduce their off-farm inputs and increase farm profits. Annette received her BS degree in Plant Biology from the Ohio State University and her PhD in Plant Biology from UC Davis. Before coming to UT in 2007, she was an assistant professor at the University of Puerto Rico. She is a northeast Ohio native but prefers winters in the Southeast.

provide that early control. Moreover, in our studies we have found that the growing point of nutsedge cannot poke through the cellulose mulch.

3) Do they fit into my current production system?
Biodegradable mulches can be made from a host of ingredients, including both biobased (feedstocks derived from renewable resources) and synthetic (feedstocks derived from fossil fuels) ingredients. Both types of ingredients will breakdown into carbon dioxide and water in the soil. In fact, some of the synthetic ingredients can breakdown faster than some biobased ingredients. However, if you are a certified organic producer, there are additional considerations around BDM use that you should be aware of and can find here, as they are beyond the scope of what we can cover today:
https://biodegradablemulch.tennessee.edu/wp-content/uploads/sites/214/2020/12/Biodegradable-Plastic-Mulch-And-Suitability-for-Sustainable-and-Organic-Agriculture.pdf

Beware! Not all mulches touted as biodegradable are equal!
With the renewed interest in biodegradable mulches, there has also been a resurgence of oxodegradable mulches. Oxodegradable mulches are made from conventional plastic, with additives that cause it to break into pieces when exposed to UV light, heat and/or oxygen. These mulches degrade very slowly in the field and are generally cheaper than a true BDM. More info on those here:
https://biodegradablemulch.tennessee.edu/wp-content/uploads/sites/214/2020/12/oxo-plastics.pdf

Can I lay them with my mulch layer?
Yes, BDMs can be laid with the same mulch layer you use for plastic mulch and drip tape. Due to the nature of these mulches, you need to make sure that the trailing wheels just rest on the mulch without applying tension. You will likely have to drive a bit slower than you might be used to with plastic mulch. This is to prevent sheering of the roll. Once you have your layer adjusted, BDMs are just as easy to lay as plastic mulch.

Other points to consider in season
While we're used to walking on and across beds of plastic mulch, BDMs will more easily tear, so a bit of retraining workers may be needed to keep the mulch intact, especially early in the season when weeds will find that light coming through the mulch hole.

For crops that rest on the mulch, we have found that mulch adhesion can be an issue (Fig.2). This is where a fragment of mulch sticks to the surface of the fruit over time. We have found this to occur in mini-pumpkins as well as larger-sized pumpkins. If harvested early, when it's dewy, these mulch pieces are easily wiped off. Later in the day, they can tend to get 'glued' on and take a bit more vigorous rubbing to remove.

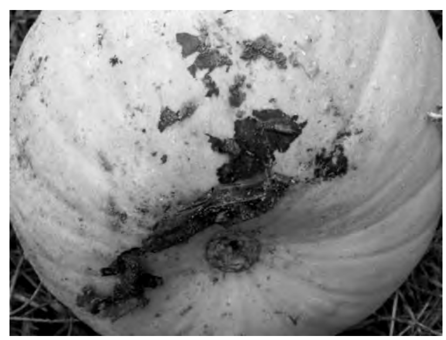

Figure 2. Mulch adhesion on pumpkin.

At season's end, drip tape must be removed and then the BDM can be tilled into the soil.

Do they yield equally well as?
In our trials, we have found no significant differences in pumpkin yield between BDMs and PE mulch in Knoxville. In Mt. Vernon, WA, our collaborators found differences in yield among the BDMs, though several were still comparable to yield with PE mulch. This is likely due to the climatic differences.

Resources:
Biodegradable Mulch Project Website- with a host of factsheets on a variety of topics around biodegradable mulches, including production, economics, grower case studies, tips and tricks
https://biodegradablemulch.tennessee.edu

TAR SPOT IDENTIFICATION AND MANAGEMENT

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Tar spot is a corn leaf disease caused by the fungus Phyllochora maydis, and is relatively new to the United States. First discovered in Pennsylvania in September 2020, this potentially yield-limiting disease arrived initially in the US in 2015 and made headlines during the 2018 growing season when there was widespread economic impact in the Midwestern states. The disease has now been found in 18 states including two counties in Maryland and 19 counties in Pennsylvania. Disease onset has been late in the season in these reported counties and no yield loss has been documented. Given the current distribution, there is a high likelihood of tar spot presence in unreported areas of these states. A map of the most current reports can be found at corn.ipmpipe.org/tarspot/.

The symptoms of tar spot are primarily the presence of glossy black, raised lesions on leaves, which may be surrounded by dead tissue as the disease progresses. These signs are easiest to see on green tissue but can also be found on dried leaves and crop residue. Tar spot is easily identified when severity is high, but at very low levels it is easy to overlook and mistake for spots caused by other fungi, aphids, insect frass, or other debris. To test spots, one may apply some water or hand sanitizer to the suspected spot, and rub gently. If the spot is removed by rubbing, it is not tar spot. Another check is to examine both sides of the leaf to see if the lesion penetrates both surfaces. Insect frass and honeydew will not be visible in the same spot on both sides of the leaves.

In severe cases, tar spot may cause yield and quality loss due to low test weight, reduced kernel fill and other issues. Little is known about how or if tar spot infection affects sweet corn flavor, but its impact on sugar production is a concern.

The fungus that causes tar spot can survive our Mid-Atlantic winters in corn residue on fields, in stover, and uncomposted animal bedding. We also hypothesize that the fungus can live and overwinter in certain grassy weeds. When the weather becomes favorable to the fungus in the summer, spores will be produced from these reservoirs and blow on the wind or splash onto fresh corn plants.

Knowing tar spot has been detected in your county or a neighboring one is not a reason to panic in the coming season. Information regarding the relative efficacy of management strategies of tar spot is still limited, but crop rotation, residue management, hybrid selection, and appropriate use of fungicides may help limit impact. While we are still learning about the conditions that favor development, growers can think about this as they do familiar leaf diseases such as gray leaf spot and northern corn leaf blight. We typically see these diseases every year, but they impact later plantings to a greater extent than earlier plantings and a standard fungicide program suppresses them nicely. Instead, knowing tar spot has been found near you means you should now be scouting for symptoms earlier in the season (say, by July 4th) so that you can track arrival and progress to inform your fungicide decisions better. Suppose tar spot is detected early in a field (like during vegetative or early reproductive growth stages), and disease-favorable weather conditions are predicted for the next few weeks (mild and moist). In that case, an application may be warranted. Because tar spot is new to the regions where we test fungicide efficacy in the northeast, we currently know very little about optimal fungicide timing. The table below is excerpted from the Crop Protection Network's 2022 Corn Fungicide Efficacy Guide to show tar spot-labeled products only (Table 1). This is based on disease control in field corn, but may be useful as a general guide. Check for updates to this in early 2023. In multi-state field corn trials, products containing two or more active fungicide ingredients have been most effective in 2021

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and 2022. Preliminary work conducted at the Southeast Agricultural Research & Extension Center in Lancaster County in 2022 showed significant reduction of tar spot symptoms on sweet corn from all tested foliar fungicide applied at tassel (Trivapro and TopGuard EQ).

If you have detected tar spot on your farm or a neighboring one, talk to your seed dealer about selecting varieties that are not highly susceptible to this disease. While no varieties are completely resistant to tar spot, seed companies are beginning to learn which are poor performers under pressure. In Pennsylvania, we have not yet had sufficient disease pressure to test the performance of the varieties in public field trials.

Finally, strategies to increase the decomposition of corn residue in an affected field may help reduce the inoculum for the next season. Realistically, the number and proximity of corn fields in our states mean that tar spot inoculum will likely be able to blow in from areas outside of your control but reducing the fungus' survival could prolong the time before the onset of disease in any given field, and this may allow you to miss a susceptible window for certain plantings of your crop.

Table 1. Fungicide Efficacy for Control of Tar Spot, Gray Leaf Spot, and Northern Corn Leaf Blight in Field Corn

Active Ingredient	Product	Rate per Acre (fl oz)	Gray Leaf Spot	Northern Leaf Blight	Tar Spot[1]
Picoxystrobin	Aproach 2.08 SC	3–12	F–VG	VG	G[3]
Tetraconazole 20.5%	Domark 230 ME	4–6	E	VG	G[3]
Benzovindiflupyr 2.9% Azoxystrobin 10.5% Propiconazole 11.9%	Trivapro 2.21 SE	13.7	E	VG	G–VG
Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima 2.34SC	3.4–6.8	E	VG	G–VG[3]
Flutriafol 19.3% Fluoxastrobin 14.84%	Fortix 3.22SC Preemptor 3.22SC	4–6	E	VG	G–VG[3]
Flutriafol 26.47% Bixafen 15.55%	Lucento	3–5.5	VG–E	VG	G
Prothioconazole 16.0% Trifloxystrobin 13.7%	Delaro 325 SC	8–12	E	VG	G–VG
Prothioconazole 14.9%	Delaro Complete 3.83 SC	8.0-12.0	E	VG-E	VG
Pydiflumetofen 7.0% Azoxystrobin 9.3% Propiconazole 11.6%	Miravis Neo 2.5 SE	13.7	E	VG–E	G–VG
Pyraclostrobin 28.58% Fluxapyroxad 14.33%	Priaxor 4.17 SC	4–8	VG	VG–E	U
Pyraclostrobin 13.6% Metconazole 5.1%	Headline AMP 1.68 SC	10–14.4	E	VG	G–VG
Tetraconazole 7.48% Azoxystrobin 9.35%	Affiance 1.5SC	10–14	G–VG	G–VG	G[3]
Flutriafol 18.63% Azoxystrobin 25.30%	TopGuard EQ	5–7	VG	G-VG	G–VG[3]
Mefentrifluconazole 17.56% Pyraclostrobin 17.56%	Veltyma	7–10	VG–E	VG–E	VG
Mefentrifluconazole 11.61% Pyraclostrobin 15.49% Fluxapyroxad 7.74%	Revytek	8–15	VG–E	VG–E	VG

1 Fungicide application timing is extremely important and needs to be made near the onset of the tar spot symptoms. Efficacy ratings based on limited site locations from 2018 to 2021. 3 A 2ee label is available for several fungicides for control of tar spot, however efficacy data are limited. Check 2ee labels carefully, as not all products have 2ee labels in all states. This information is provided only as a guide. It is the applicator's legal responsibility to read and follow all current label directions. Reference in this publication to any specific commercial product is for general information only and does not constitute an endorsement or recommendation by the CDWG. Individuals using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the CDWG assume no liability resulting from the use of these products.

WEED MANAGEMENT IN SWEET CORN

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Sweet corn growers have many more weed management tools at their disposal now, compared to 10-15 years ago. Even though more products are now available, weed control in sweet corn can still be a challenge on certain weed species (see Table 1.). However, over the past several years some newer herbicide products have been labeled for use in sweet corn that could provide effective control of problem weeds. Historically, weed control in sweet corn has primarily been limited to soil-applied materials. Currently, some newer preemergence and postemergence herbicides are available. Products such as Acuron, Armezon Pro, Anthem Maxx, Liberty, Restraint, Revulin Q, Shieldex, Solstice, Verdict, and Zidua SC now can be used in sweet corn production. These products generally provide effective weed control and exhibit good crop safety in field corn, however some research has been conducted with them in sweet corn in Pennsylvania and the Mid-Atlantic region. Initial results of these studies have found that: 1) under heavy weed pressure, a full rate of residual herbicide followed by a postemergence application was needed for consistent weed control; 2) the newer herbicides (Acuron, Revulin Q, Solstice, Liberty, and Armezon Pro) performed comparable to Lumax, Accent, and Impact in terms of crop safety and yield and; 3) across two years and two locations, a trend was observed for more sweet corn injury and a negative effect on yield with Zidua and Verdict plus atrazine. Also, with more weeds becoming herbicide resistant it is critical that growers use other effective modes of action to combat this problem. Some of these new products can help.

Newer GMO sweet corn varieties that are resistant to Roundup and Liberty are currently available for use. These varieties can be valuable since glyphosate and Liberty (glufosinate) provide broadspectrum weed control with no soil residual issues that could interfere with rotational crops. Due to the increasing number of glyphosate resistant weed species, Roundup Ready sweet corn varieties may be less attractive. However, treatments that include Liberty in LibertyLink variety may still have utility.

Table 1. Effect of common sweet corn herbicides on selected weeds

Weeds	Bicep II Mag	Lumax	Impact/ Armezon	Laudis	Callisto	Accent Q	Cadet	Sandea
Giant foxtail	**9**	**9**	7	8	N	**9**	N	N
Lg. crabgrass	**9**	**9**	8	8	8	7	N	N
Fall panicum	**9**	**9**	8	6	N	**9**	N	N
Yellow nutsedge	**8+**	**8+**	7	7	7+	6	N	**9**
Lambsquarters	**9**	**9**	**9**	**9**	**9**	6	8	N
TR Lambsquarters	7	**9**	**9**	**9**	**9**	6	8	N
Nightshade	**9**	**9**	**9**	**9**	**9**	N	6	6
Pigweed	**9**	**9**	**8+**	**8+**	**8+**	**9**	**8+**	**9**
Common ragweed	**8+**	**9**	7+	7+	8	6	6	**8+**
Smartweed	**9**	**9**	**9**	**9**	**9**	8	N	8
Velvetleaf	**8+**	**9**	**9**	**9**	**9**	7	9	**9**
Cocklebur	**8+**	**8+**	**8+**	**8+**	**8+**	7	N	**9**
Ann. morningglory	**8+**	**8+**	7+	7	7+	7	7	6
Canada thistle	**7**	**7+**	7	7	8	6	6	8 (+2,4-D)

Weed control rating scale: 9 = 85-95%; 8 = 75-85%; 7 = 65-75%; 6 = 55-65%; N = no activity

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.

Glyphosate-resistant marestail/horseweed

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

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

The number of herbicides that are effective on marestail is rather limited in vegetable production systems. However, certain sweet corn herbicides can provide control of marestail. Here are some suggestions: In no-till sweet corn, paraquat plus a triazine herbicide, and glufosinate plus atrazine applied burndown for control of emerged seedlings and residual control of glyphosate- and ALS-resistant horseweed. 2,4-D and Sharpen can be used in the burndown program but it is best to wait 7-14 days before planting otherwise crop injury can occur. If using atrazine alone or in premix products such as Bicep, Lumax, Acuron, etc, it will provide good residual control of marestail but does not control it if its emerged. 2,4-D is an effective postemergence herbicide if it is applied before marestail reaches 4 inches tall. Otherwise, for small, emerged marestail, foliar-applied HPPD inhibitors (e.g., Callisto) plus atrazine are effective. Liberty (flufosinate) is very effective on marestail postemergence, so consider a LibertyLink variety if it's a problem.

Cover crops (e.g., cereal rye) can help to suppress marestail growth during the winter and spring months allowing for fewer and smaller marestail making the burndown herbicide program more effective. Also, if using a cereal cover crop, 2,4-D or dicamba can be applied in the fall to control small marestail seedlings or 2,4-D could be applied in the spring when the rye is less than a foot tall to control to obtain control of marestail. Then the rye can continue to grow before it is terminated and/or rolled down before sweet corn planting.

For those using a tilled seedbed, marestail usually is not an issue in this setting since the tillage process controls existing seedlings and buries the seeds deep enough to manage them for that growing season. However, using effective residual herbicides can insure none will establish while the crop is growing.

Other issues in sweet corn production

As more producers are using no-till farming techniques for vegetable production, herbicide programs play a key role in effective weed management. Yet many growers want to move to the next level and produce sweet corn in no-till setting and without the use of long residual herbicide such as atrazine. Atrazine continues to be a very effective yet economical herbicide for broadleaf weed control in sweet corn. Over half of the herbicides labeled for use in sweet corn contain atrazine or recommend atrazine as a tank-mix partner. Pennsylvania producers likely use atrazine on a high percentage of the sweet corn acres. Despite its wide acceptance by producers, atrazine use in crop production systems is a controversial issue for various reasons including environmental issues and resistant weeds. In addition to these concerns, atrazine can cause problems with rotational crops, especially vegetables, and cover crops after sweet corn production. Many growers have inquired about herbicide programs that do not contain atrazine to potentially alleviate carryover problems with successional crops. Other herbicides such as mesotrione (Callisto), topramezone (Impact/Armezon), and pyroxasulfone (Zidua) also, potentially can leave residues causing injury to rotational crops. However, these can vary depending on use rates, soil types, rainfall, and other environmental conditions.

Atrazine does improve control of certain weed species (as is well documented through various research) and is still a very effective yet economical herbicide for broadleaf weed control in sweet corn, including no-till systems. However, depending on weed species present, reducing the rate of atrazine or eliminating it could be possible if there are concerns about carryover to rotational crops, especially vegetables, and cover crops following field or sweet corn production. Problems with atrazine residues causing injury to rotational crops varies depending on use rates, soil types, rainfall, and other environmental conditions. *However, simply replacing atrazine with another product such as an HPPD- or PPO-inhibiting herbicide (Acuron, Callisto, Impact/Armezon, Laudis, Verdict) will not necessarily eliminate the aforementioned concerns.* Several of these types of products have stringent crop rotation restrictions as well. Only a few herbicides have short rotations for a multitude of crops. Liberty can have a good fit in sweet corn production in a LibertyLink sweet corn system. Roundup Ready varieties also can have a good fit as well. However, limited variety options, cost of these technologies (e.g., seed tech fees), resistant weed species (esp. glyphosate), and customer apprehension about these genetically modified varieties may limit their widespread use.

Postemergence herbicides should only be used in sequence after a soil-applied herbicide. Total-post weed control is not recommended because sweet corn seedlings are very non-competitive with weeds, and weather conditions that prevent postemergence herbicide application may delay weed control until it is too late to prevent loss. Having a soil-applied herbicide down improves overall weed control, provides additional herbicide modes of action for resistance management, and provides some insurance in case postemergence herbicides cannot be sprayed on time. In previous Penn State research, a two-pass system provided more effective weed control overall compared to a single application timing especially in no-till systems. Spray the post treatment when weeds are small (<3 inches tall). For best results, fields with heavy populations of annual grasses (foxtail, crabgrass, panicum) will require a PRE followed by POST herbicide program for consistent control.

Depending on the program, common ragweed may require a two-pass program for adequate control. Also, control of annual morningglory, Palmer pigweed, and waterhemp are a few species that could be a problem depending on which herbicide program is used. Palmer amaranth and waterhemp are becoming a problem in various parts of PA. These noxious pigweeds are very aggressive and can be difficult to control in certain cropping systems. There are certain herbicides in sweet corn that provide control of Palmer and waterhemp including atrazine, acetochlor-products, Lumax, Zidua, Callisto, Impact/Armezon, Laudis, Liberty 280, 2,4-D and a few others. Again, two-pass systems work best and are usually necessary with Palmer amaranth/waterhemp since it has a long germination period. And control of these weeds after sweet corn harvest may be essential to stop seed production and additional spread.

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POLLINATION CONTRACTS: PANEL DISCUSSION

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Mark Gingrich is a commercial, sideline beekeeper and the owner of Gingrich Apiaries, LLC in Dover, PA where he manages in excess of 250 colonies for pollination, production of honey and queen rearing. The operation produces an average of 300 mated queens annually sold across the US. He is the president of Pennsylvania State Beekeepers Association, a founding member and Co-Chair for the Pennsylvania Queen Bee Improvement Project, a certified EAS master beekeeper, member of the Pennsylvania Department of Agriculture apiary advisory board, Penn State Ag Council, stake holder in the COMB and CARE projects, long time participant in numerous USDA funded SARE (Sustainable Agriculture Research & Education) grants focused on bee genetics, and instructor at the Horn Farm Center for Agricultural Education. He is active in many Pennsylvania county bee clubs. Mark grew up in 4-H and FFA and remains closely connected to agriculture. He is currently an executive board member of the Pennsylvania State Council of Farm Organizations and actively speaking on various beekeeping topics across the northeastern states.

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Lindsey Moroch is Owner Operator of Kutik's Everything Bees, which strives to provide the best in honey bee education and resources. As Director of Operations for Kutik's, Lindsey has gained a unique perspective and understanding of the apiary industry, pollination services, nucleus colony and honey production. An avid lover of honey and the honey bee, Lindsey speaks to everyone from lawmakers in Albany, NY. to our future farmers and innovators in kindergarten. Lindsey is based out of Oxford NY with her family.

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Grant Stiles is a Certified Master Beekeeper, has a degree in entomology from Penn State University, and was the Jersey State Apiarist for 10 years. During his tenure as state apiarist, Grant learned about the industry of commercial beekeeping and obtained the tools he needed to successfully run Stiles Honey. Stiles Honey is one of the most successful apiaries in the New York/New Jersey area, currently managing well over 4,000 honeybee colonies.

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During this panel discussion, we will discuss:

1. How farmers and beekeepers get connected.
2. How to determine stocking rate, pollination duration, and colony strength.
3. Pollination contracts
4. What farmers should do while the bees are on site to protect them from harm
5. Questions from the audience.

BUMBLEBEES IN GREENHOUSE AND FIELD CROP PRODUCTION

Agrin Davari, Plant Products

The importance of pollination services from managed and native bees to our agriculture and economy is of great political, scientific, and public interest. Bees are essential for a stable and healthy food supply. More than 90% of the leading global crops rely on bees for pollination. In the past, growers relied on honeybees, manual pollination and hormones, depending on the crop. All these methods have disadvantages. In general, honeybees don't work well in greenhouses or tunnels. They are generally less effective or inadequate during periods of low temperatures (<15°C/59°F) and cloudy weather. Manual pollination is time consuming and difficult to manage and the use of hormones often results in low quality fruits, which are not suited for export (soft, malformed and seedless fruit). Studies show that bumblebees have a lifestyle and foraging behavior that fits better for protected environments such as greenhouses. Bumblebees are excellent pollinators in many crops. They are incredibly versatile and have some big advantages over honeybees in a number of different situations which results in higher fruit quality, quantity, and even considerable labor saving. Bumblebees have a special way of pollination called "Buzz Pollination" or sonication. It's a rapid vibrating motion which dislodge large amount of pollen from the flower. This vibration is caused by rapid movements of the flight muscles while the wings are disconnected. Buzz pollination allows bumblebees to pollinate a flower in a single visit and spend less time per flower, resulting in a higher flower visit ratio. At Plant Products – A member of Biobest group, we provide tailor-made advice to ensure growers deliver higher volumes of larger, high quality fruit throughout the season.

Agrin Davari is an IPM Specialist at Plant Products – A member of Biobest group. She joined Biobest in 2021 after finishing her PhD in Entomology at The University of Vermont. Agrin's research background includes applying advanced molecular, biological, and cultural techniques to control arthropod pests in greenhouses. In her current position as an IPM Specialist, she helps growers to practice and implement strategies to keep their pests below economic threshold with emphasis on the least toxic approaches. She also provides expert advice on using bumblebees for pollination in field and greenhouse crops to achieve the highest possible crop yields.

POTATO INSECT PEST UPDATE

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Colorado potato beetle remains a major pest of potatoes across the U.S. including the mid-Atlantic Region. Since the mid-1990s, systemic neonicotinoid insecticides such as Admire Pro, Platinum 75SG, Belay, or seed treatments such as Cruiser Maxx have provided excellent control of this pest. However, the inherent ability of this pest species to develop resistance to insecticides has led to reduced efficacy or residual efficacy of these insecticides on CPB. Furthermore, adult beetles that develop on volunteer potatoes in adjacent fields often move into potato fields after the residual efficacy of neonicotinoids is gone. In addition, for various regulatory and/or marketing reasons, some growers cannot use neonicotioids on their crops. This has created a greater need for foliar-applied insecticides to control CPB, and, as history has taught us, rotating modes of action is a wise strategy to prevent resistance development in CPB (Huseth et al. 2014).

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 **Open-Access**

Entomologists are continuously evaluating insecticides for use in potatoes and other crops. In 2022, we conducted several randomized & replicated small plot experiments in Virginia testing various new chemistries on CPB.

Experiment 1 was conducted at the Virginia Tech Eastern Shore AREC, Painter, VA, where potatoes (var. Envol) were planted 4 March 2022. Plots were sprayed twice at peak larvae (18 and 26 May). Treatments included Torac (tolfenpyrad, a group 21 METI insecticide that disrupts cellular respiration), and Harvanta (cyclaniliprole, a group 28 diamide insecticide). Both insecticides provided excellent control of CPB larvae under high pressure (Table 1). Both Torac and Harvanta are registered for use on potatoes and also effective on other potato pests such as potato leafhopper, aphids, and lepidopteran larvae like armyworms or European corn borer.

Table 1. Potato foliar insecticide evaluation trial #1 conducted in Painter, VA 2022.

		# Colorado potato beetles / 10 stems			
		28-May (2 DAT)		1-Jun (6 DAT)	% defoliation 9-Jun (14 DAT2)
Treatment*	**Rate/A**	**Small larvae**	**Large larvae**	**Large larvae**	
Untreated Check	-	75.0 a	69.5 a	25.5 a	77.5 a
Torac	14 fl oz	0.0 b	1.0 b	0.5 b	7.5 b
Torac	21 fl oz	1.3 b	0.3 b	0.5 b	7.3 b
Harvanta 50SL	5.5 fl oz	0.5 b	0.3 b	0.0 b	4.3 b
P-value from Anova		<0.0001	0.0017	<0.0001	<0.0001

*The adjuvant DyneAmic @0.125% v:v was included with all insecticide treatments.
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).

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 35 graduate students and has published over 140 peer-reviewed papers and 7 book chapters on insect pest management in agricultural crops. A native of Baltimore, MD, he received his B.S. in biology from Towson University in 1992 and his Master's (1996) and Ph.D. (2000) degrees in entomology from Virginia Tech.

Experiment 2 was also conducted at the same location Painter, VA, where potatoes (var. Envol) were planted 4 March 2022. Plots were sprayed twice in mid-May initiated at 50% egg hatch. Treatments included the group 28 diamides Coragen and Vantacor (each contains the same active ingredient, chlorantraniliprole, but Vantacor is a more concentrated formulation), as well as the spinosyn insecticide Blackhawk. All three insecticides provided effective control of CPB with 2 applications (Table 2). These three products also provide control of lepidopteran pests, but not potato leafhoppers, and all three are registered for use on potatoes.

Table 2. Potato foliar insecticide evaluation trial #2 conducted in Painter, VA 2022.

		# CPB per 10 stems				
Treatment	**Rate/Acre**	**19 May small larvae**	**19 May large larvae**	**23 May small larvae**	**23 May large larvae**	**% defoliation 3 Jun**
Untreated Check	-	122.5 a	8.0	77.3 a	171.8 a	80.0 a
Coragen 20SC	5 fl oz	n/a	n/a	0.0 b	0.0 b	3.3 b
Vantacor	1.66 fl oz	0.0 b	0.0	0.0 b	0.0 b	3.3 b
Blackhawk	3 oz	28.5 b	0.3	1.0 b	0.3 b	9.3 b

*The adjuvant DyneAmic @0.125% v:v was included with all insecticide treatments.

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).

Experiment 3 was also conducted at the same location Painter, VA, where potatoes (var. Envol) were planted 4 March 2022. Plots were sprayed up to 4 times as noted. Treatments included a grower standard, Coragen, (chlorantraniliprole, a group 28 diamide) as well as Calantha, (a novel RNAi insecticide from Greenlight Biosciences). To test another IRM strategy for CPB (tank mixing insecticide modes of action), this experiment also included various rotations and mixtures that included Rimon EC (novaluron, a Group 15 insect growth regulator), Assail (acetamiprid, a Group 4 neonicotinoid), Bifenture (bifenthrin, a Group 3 pyrethroid), Lambda-cyhalothrin (another pyrethroid), AgriMek (abamectin, a Group 6 avermectin), and Argyle OD (a mix of acetamiprid + bifenthrin). All insecticide treatments and rotations resulted in effective control of CPB reducing defoliation to <5% compared to >68% in the untreated plots (Table 2).

Table 3. Potato foliar insecticide evaluation trial #3 conducted in Painter, VA 2022.

		# Colorado potato beetles / 10 stems				
		23-May		31-May		
Treatment	**Rate/Acre**	**Small larvae**	**Large larvae**	**Small larvae**	**Large larvae**	**% defoliation**
Untreated Check		73.5 a	113.8 a	6.8 a	30.5 a	68.3 a
Rimon EC (4 apps[1]) then Assail 30SG + Bifenture LFC (17 May)	6 floz 4 oz + 24 floz	0.0 c	0.0 b	0.0 b	0.0 b	2.0 b
Rimon 0.83EC (3 apps2) Assail 30SG + Bifenture LFC (17 May)	8 floz 4 oz + 24 floz	0.0 c	0.0 b	0.0 b	0.0 b	2.0 b
Rimon 0.83EC (4 apps[1]) Assail Liquid + Bifenture LFC (17 May)	6 fl.oz 3.3 floz + 24 floz	0.0 c	0.3 b	0.0 b	0.0 b	2.3 b
Lambda-Cy + AgriMek Assail 30SG + Bifenture LFC	3.8 floz + 3.5 floz 4 oz + 24 floz	0.0 c	0.0 b	0.0 b	0.0 b	2.0 b
Lambda-Cy + AgriMek Argyle OD (12, 19 May)	3.84 floz + 3.5 floz fb 9 floz + 24 floz	0.0 c	0.0 b	0.0 b	0.0 b	2.0 b
Calantha (3 apps[2])	16 floz	29.0 b	5.8 b	8.0 a	7.3 b	5.0 b
Coragen (17 & 23 May)	5 floz	1.3 c	0.3 b	0.0 b	0.0 b	2.3 b

1-On 26 Apr, 3, 10, 17 May. 2-26 Apr, 3, 10 May.

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).

Experiment 4 (ORGANIC) was also conducted on organic potatoes in Whitethorne, VA, planted 15 May 2022. Treatments were all organic-certified and included the spinosyn Entrust, Aza-Direct, which includes azadirachtins derived from the neem tree, Azera, which contains both azadirachtins and pyrethrins derived from Chrysanthemum flowers, as well as Trident, which contains Bt tenebrionis bacterial crystalline proteins that disrupt the midgut of beetles. Unfortunately, after what looked like an increasing CPB pest infestation, the numbers of larvae crashed after one insecticide application. However, from what we could sample after 1 week post spraying, all treatments appeared to reduce CPB larval numbers (although we were not able to get statistical significance because of one untreated control rep having no beetles) (Table 4).

Table 4. Organic potato foliar insecticide evaluation trial #4 conducted in Painter, VA 2022.

Treatment	Rate/Acre	# CPB larvae/ 5 plants 5 Jul (4 DAT)	# CPB Larvae + Adults/ 5 plants 12 Jul (11 DAT)
Untreated Check	-	15.2 ± 22.7	1.3 ± 1.9
Trident WG Low	16.0 oz	3.3 ± 4.6	0.8 ± 1.0
Trident WG High	25.0 oz	1.8 ± 3.5	0.0 ± 0.0
Azera	32.0 fl. oz	8.8 ± 14.2	0.0 ± 0.0
Aza-Direct	32.0 fl. oz	4.5 ± 8.4	0.0 ± 0.0
Entrust SC	5.0 fl. oz	0.0 ± 0.0	0.3 ± 0.5

MANAGING BLACKLEG AND SOFT ROT OF POTATO FROM SEED TO FIELD AND STORAGE

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Blackleg and soft rot (BSR). BSR is an economically important and sometimes devastating disease of potatoes. It impacts plant emergence, yield, and tuber health. Loss may occur during the growing season, storage, transit, or marketing. In 2015, there was an outbreak of BSR that drastically impacted potato production in the Northeastern region of the United States, causing a shortage of potato seed and the loss of some businesses due to seed contamination. BSR is caused by several closely related bacterial species under the genera of *Dickeya* and *Pectobacterium* and is considered a seed-borne disease. Both stems (showing blackleg symptoms) and tubers (showing soft rot symptoms) can impact the production of potatoes.

The pathogens and their survival. The pathogens are found widely in the world; however, their taxonomy varies depending on the region and climate. *Dickeya dianthicola* is the predominant species in the outbreak, observed in the field potato crop. After the first year of epidemics, *Pectobacterium parmentieri* has been frequently detected and became a concern as it caused more damage in the storage. Other bacteria that have been found in association with BSR in the Northeastern US include *D. polaris, D. dadantii, D. atroseptica, D. zeae, P. brasilliense,* and *P. versatile.* Noticeably, *P. versatile* has taken the top among all the species, and *D. aquatica* isolated from water (no host found) can cause severe BSR on potatoes.

The pathogens do not survive well in soil. However, they may stay in the water for at least a year. Therefore, cool and wet soils that are overly irrigated can extend the existence of the bacteria. The pathogens grow at temperatures from 32 to 90 F, with optimal growth between 70 and 80 F. If environmental conditions trigger its dormancy, the bacterium can survive for long period and also become more tolerant or resistant to disinfection agents or antibiotics. In the field, the bacteria can be spread rapidly by wind-blown rain.

Storage decay. The pathogens reside on the surface of potato tubers at harvest and enter the deep tissues via natural openings such as eyes and lenticels, as well as wounds. Depending on environmental conditions, infected potato tubers in the storage either develop soft rot symptoms or carry the pathogen over to the field when used as seed pieces. Under 45 F, which is the temperature of most storage facilities, the bacteria stay inactive or dormant until they are moved to the field for planting. Un-conditioned storages (>45 F) have had a huge loss to soft rot in recent past years. Warm, moist, and anaerobic conditions favor disease development in storage. High moisture can form a water film resulting in a tuber being anaerobic which favors the pathogen. As the soft rot develops, the tissues of potato tubers will further get degraded, and the decayed tissues continue to contaminate more tubers in the pile of potatoes.

Disease epidemics in the field. Seed tubers carrying the pathogens may be decayed after planting and result in missed emergence. After planting, the pathogen starts to be active due to the increasing temperature and potato root exudates. Both tubers and stems can express symptoms. The pathogen then moves from rot (mother) tubers to stems via vascular systems, or to daughter tubers via stolon. Infected plants show inky black stems, discolored vascular tissues, and yellow and wilt leaflets, and eventually, decline.

The disease progress of BSR is favored by high moisture and high temperatures. The higher temperatures are, the faster the disease progresses. Higher soil temperatures at planting favor seed piece decay and preemergence death of shoots. The pathogen is spread from seed piece to seed piece by physical handling, cutting, and planting equipment. Multiple bacterial species may synergistically cause higher severity than that caused by one species. Early tuber contamination, such as at harvesting or before storage has a higher chance to infect field plants. Surface water used for irrigation can be a source of bacterial contamination.

Managing BSR. Because the pathogens are mostly seed-borne and anaerobic, the key to BSR control is to start with seed cleaning, aeration, and water control. Potato tubers can be contaminated anytime, including during harvest, handling, and washing. Therefore, any practices eliminating tuber contamination can be helpful. Tuber bruising and mechanical damage are the most important pathways of bacterial entry. Sanitation and disinfection during seed cutting can avoid cross-contamination. Higher temperatures (> 80 F) can make tubers more venerable to soft rot, so wet and hot conditions should be avoided during harvesting. Good air circulation helps to suppress the disease in storage. Although all potato varieties are susceptible, some varieties are more tolerant, such as Caribou Russet, Snowden, Dark Red Norland, Katahdin, and Shepody.

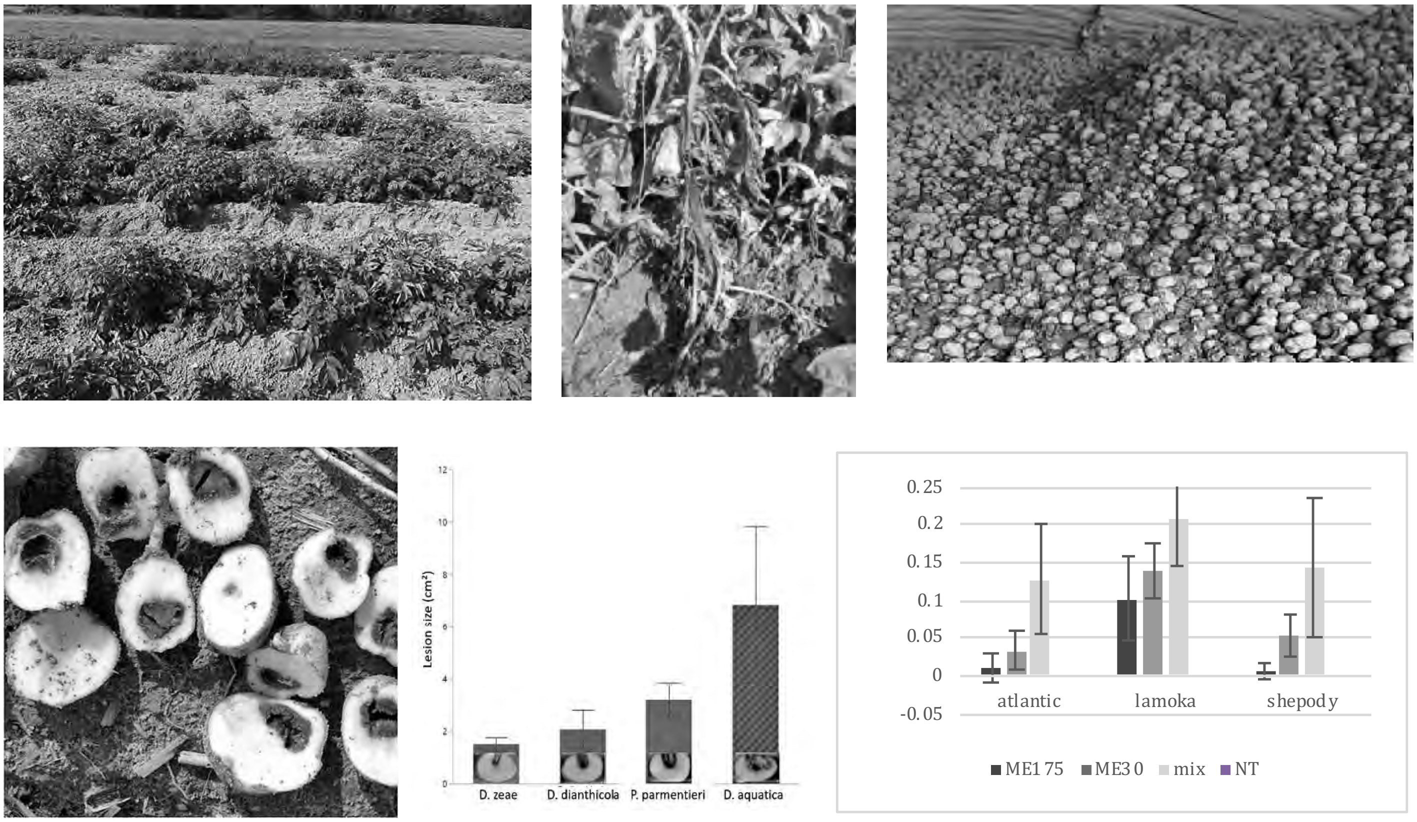

Figure 1. Symptoms of potato blackleg and soft rot and pathogenicity of the pathogens. Top left: low emergence due to contamination of potato seed pieces. Top middle: dark and necrotic stem caused by the pathogenic bacterium *Dickeya dianthicola*. Top right: potato soft rot in storage caused by *Pectobacterium parmentieri*. Bottom left: soft rot inside potato tubers. Bottom middle: virulence of bacterial species causing potato soft rot. Bottom right: blackleg of potato varieties ‘Atlantic’, ‘Lamoka’, and ‘Shepody’ in the field infested with *Dickeya dianthicola*, *Pectobacterium parmentieri*, or mixture of the two species.

MANAGING NITROGEN AND OTHER NUTRIENTS ON PA POTATOES

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Managing fertilizer inputs, especially nitrogen, is critical for growing a successful potato crop. The high cost of fertilizers puts greater importance on applying the right amount to the crop's need. Applying excess (i.e. nitrogen) can cause excessive crop vigor, leading to greater instance of disease severity and lack of plant maturity at the end of the season. Environmental regulations and social pressures are leading to greater scrutiny of fertilizer inputs as well.

Factors that Influence Nitrogen Needs

Variety release reports or agronomic sheets will give a general nutrient guide for that variety's specific needs. Sometimes these reports include all nutrients, other times it is nitrogen only. Soil and environmental conditions of the variety's breeding origin can influence these listed amounts, unless stated otherwise. Seed growers often have these documents, or they can be obtained from the original breeder of the variety.

Past applications of manure can collectively lead to some nitrogen remaining in a field. This amount will vary by manure source, dry matter percentage, and time elapsed (years) from application. Cornell University Extension's Agronomic Fact Sheets offer charts and information regarding specifics of manure nitrogen credits.

Crop history, including cover crops, can offer significant nitrogen to a potato crop. Established pastures, hay fields, and alfalfa can offer the majority of needed nitrogen. Each field needs to be evaluated on a case-by-case basis, but nitrogen can easily amount to 50 units. Soybeans can offer 20-40 units if the crop was vigorous and high yielding. Leguminous cover crops and cool grass mixtures contribute varying amounts, dependent on age and height of the crop. High residue cover crops (i.e. mature rye stands) or full season crops with high residue (corn and wheat) offer little to negative nitrogen contributions due to their high carbon to nitrogen ratios. Cornell University Extension's Agronomic Fact Sheets offer estimates on both rotational and cover crop nitrogen contributions; re-evaluating theses estimates to a specific growing region will offer the best results.

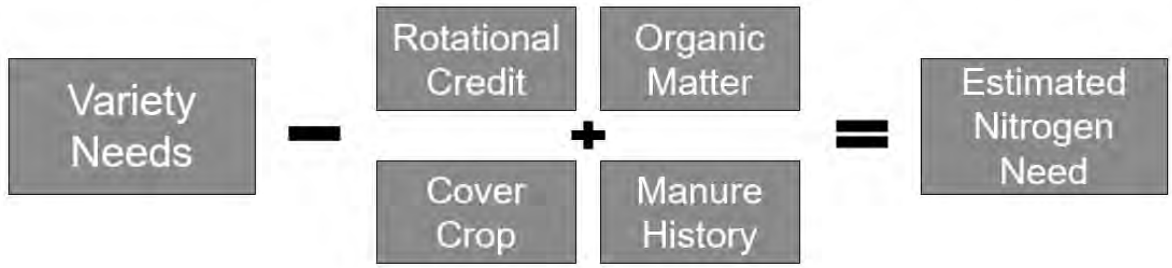
Soil organic matter can contribute high amounts of nitrogen for a given season. Estimates vary greatly depending on soil type. Generally, it is best to use conservative amounts when deciding credits; 40 units is usually the cap for nitrogen contribution. Most regular soil test results will contain percent organic matter. The chart below shows some estimates for a Pennsylvanian mineral soil (Calvin/Leck Kill soil type).

Soil OM %	<1	<1.5	<2	<2.5	<3	<3.5	<4
Nitrogen Estimate	0 lbs	10 lbs	15 lbs	20 lbs	25 lbs	30 lbs	35-40 lbs

Jonathan Price is the Senior Agronomist for Sterman Masser Potato Farms. He oversees all potato and grain scouting while also managing on-farm research, agronomics, and farm data management. Jonathan attended Cornell University and earned a bachelor's degree in Plant Science; while there he also worked for the Cornell Potato Breeding Program. Jonathan is a Certified Crop Advisor and lives in Drums, Pennsylvania.

Calculating Nitrogen Credits

Take the sum of estimated nitrogen credits from the previous rotation, cover crops, manure history, and soil organic matter and subtract it from the varietal needs.



The estimated nitrogen amount is the theoretical needs of the potato crop from outside sources. Many forms of fertilizer (liquid and granular, conventional and organic) offer nitrogen. Decide what works best to suit the grower and the grower's equipment. Nitrogen is best when applied closer to the growing season and the plant's needs. Typically, apply half at the time of planting and the remaining portion prior to hooking/tuber initiation.

Other Nutrient Needs

Potatoes need phosphorus, potassium, sulfur, calcium, and magnesium in addition to nitrogen. The University of Minnesota Extension offers the following nutrient needs to grow a 400 cwt/ac crop:

- 34 lbs Phosphorus
- 267 lbs Potassium
- 49 lbs Calcium
- 37 lbs Magnesium
- 18 lbs Sulfur

Some of these nutrients can be broadcast spread prior to the start of the season; others should be applied in a starter band at planting (i.e. phosphorus). A successful potato crop also needs zinc, iron, copper, and boron in smaller amounts. Many different products and foliar fertilizers offer these micronutrients. Healthy soils with high organic matter and/or manure history are less likely to need micronutrient inputs.

Petiole Sampling

Petiole sampling offers an in-season snapshot of the potato plant's uptake of nutrients, prior to tuber bulking. This can serve as a proxy to assess a grower's nutrient regimen, and to see if the plant is lacking a specific nutrient. Corrective action in the season, such as applying more nitrogen, does not guarantee increased yield as the plant's potential may be already stunted.

Collect samples in the morning, prior to hot temperatures. Sample the 4th mature petiole from the top of the plant. Avoid headlands, wet spots, and edges of the field. 30-40 petioles is generally optimal for testing, but always consult the plant analysis lab for their specific collection protocols. Do not collect samples all from one area - vary sampling throughout the field.

POTATO PINK ROT AND MANAGEMENT

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Potato pink rot. Since it was first observed in 1909 in Ireland and in 1938 in the United States, potato pink rot caused by Phytophthora erythroseptica has been a problem in most potato production regions. Significant yield losses have been reported due to the P. erythroseptica infection. Pink rot is a soilborne disease. Although the upper parts of potatoes can be occasionally infected, the more obvious symptom is overserved as the tuber decays. Infected tissues become rubbery in the early stages and completely rot as the symptom further develops.

The pathogen. The pathogen P. erythroseptica produces oospores in sexual reproduction. Oospores have a very thick cell wall that helps them survive extreme environments through the winter and can stay alive in the soil for up to 10 years. Under optimal conditions, oospores germinate to serve as primary inoculum early in the season. Phytophthora erythroseptica also produces sporangia in asexual reproduction. Sporangia can directly germinate and infect potato roots and tubers when the temperature is high. At a lower temperature, sporangia start producing massive single-cell zoospores, which can germinate and infect potatoes. Infection usually starts at stolon, eyes, lenticels, and wounded tissues of potato tubers. Among these inoculums, zoospores are the most efficient structure for infection.

Quorum sensing regulating zoosporic behavior. Zoospores of P. erythroseptica produce some chemicals (signal molecules) that regulate biological activities. The zoosporic population must be above a threshold before they can infect host plants. This is mechanism is called quorum sensing. Amino acids such as leucine and isoleucine have been determined to be signal molecules that direct the initiation of zoosporic germination and plant infection. These signal molecules have not only been found in P. erythroseptica but also in most oomycetes that are closely related to P. erythroseptica, as well as in several other fungi and bacteria. Pink rot-susceptible potato varieties exudate high concentrations of these signal molecules. This finding can be used to aid potato breeding for disease resistance.

Management of pink rot. Cultural practices can be arranged and make the conditions to be less favorable for plant infection. Although the survival of oospores of P. erythroseptica within infected plant debris and in the soil makes the control of pink rot difficult, rotating non-host crops with potatoes for at least four years may be an option to reduce pink rot severity in heavily infested fields. We should avoid planting potatoes in fields without pink rot history, avoid excessive irrigation but plant potatoes in well-drained soils, time vine kill and harvest to promote skin maturation and improve tuber handling processes to reduce tuber wounding during harvest, transportation, and storage.

Selecting appropriate varieties is an effective strategy. Although no variety is completely resistant to pink rot, several varieties have shown tolerance. 'Atlantic', 'Butte', 'Russet Burbank', and Snowden' have relatively high tolerance to the pathogen, while 'Lamoka', 'Goldrush', 'Yukon Gold', 'Pike', "Atlantic', 'Superior', and 'Shepody' are the most tolerant varieties.

Fungicides are the most effective tool for controlling pink rot. The products are typically applied in-furrow at planting. Phenylamide fungicides, such as metalaxyl (trade name: Ridomil) and mefenoxam (trade name: Ridomil Gold) used to be effective but have been overcome by the pathogen due to quickly developed fungicide resistance. Although Phostrol (phosphorous acid) shows high efficacy, which can be used for foliar and in-farrow applications. Presidio (a.i. fluopicolide) and Orondis (a.i. oxathiapiprolin) are effective when applied for soil treatment.

Some non-chemical and biological control agents have shown some efficacies, but their consistency may vary depending on locations and years. Regalia (plant extract) and Bacillus (such as MBI-110 and Serenade) products have been proven to be effective.

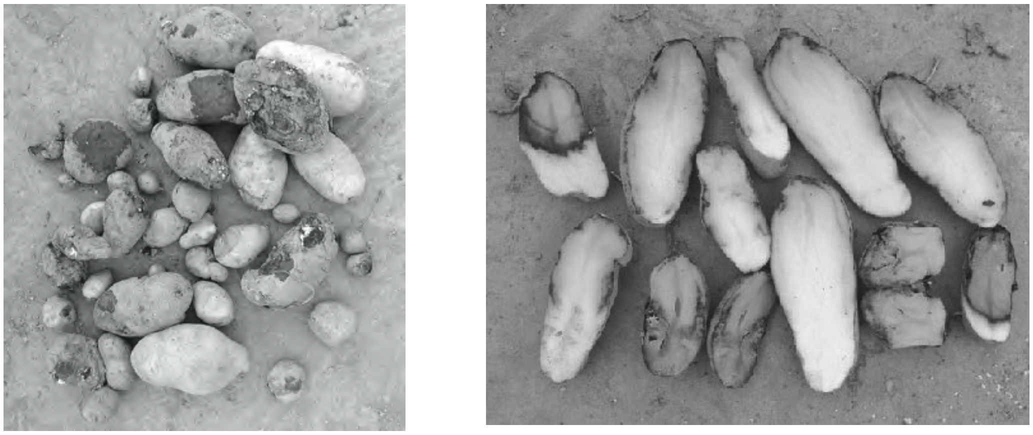

Figure 1. Potato pink rot symptoms infected by Phytophthora erythroseptica. Left: potato tubers infected in the field. Right: Infected potato tubers showing pink-colored symptoms when cut through.

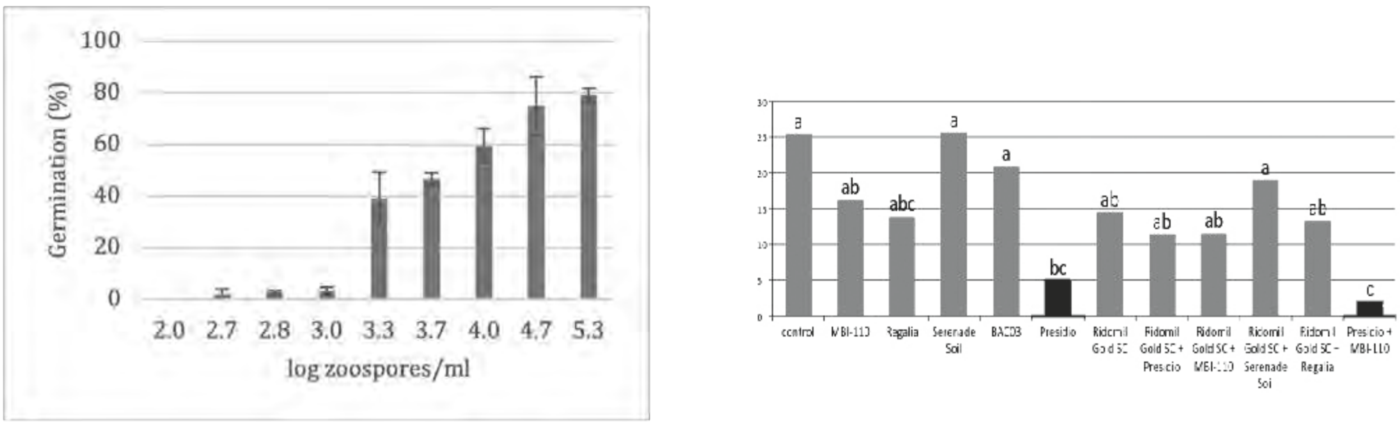

Figure 2. Effect of zoospore concentration on the germination of Phytophthora erythroseptica (left) and management of potato pink rot with chemical and non-chemical products (right).

PROTECTING YOUR INTELLECTUAL PROPERTY

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If you have developed a system or method that is unique and you wish to commercialize it, you do need to understand the protections available to you and what their limits are. You also need to understand what options for developing your idea and set realistic expectations of what you hope to get out of protecting your idea. Presumably, you've solved a problem that you have and you expect that others with the same problem would benefit from that solution and you are looking for some return on whatever investment in time and resources that is needed to make that solution marketable.

There are different categories of Intellectual Property that each protect something different and each have different deadlines, costs, and registration/application regimes. Intellectual Property in general is an asset that can be bought, sold, put in a will, or licensed in whole or in part. It can also be owned by multiple parties, but ownership each type of Intellectual Property means different things for different types of Intellectual Property. Intellectual Property is also geographic in scope – a U.S. Patent is only effective in the United States; a trademark that is not registered is effective only in those geographic areas in which it is in use, etc. But no matter what, Intellectual Property is only as strong as it is enforced, and the only ones entitled to enforce a piece of Intellectual Property are the owners of that Intellectual Property.

Regardless, it is a good idea to speak with an attorney before you disclose your intellectual property or make a sale or offer for sale. Whether or not you intend to file a patent, it's best to know what your options are before you make a decision that can't be taken back.

Patents

Patents protect new and useful ideas and inventions. This includes processes, machines, compositions of matter, methods, or any improvements to existing technologies. In every instance, the invention must have novelty which means it has to be a new idea and nothing exactly like the invention must exist before the date of filing a patent application. It also must be a not obvious variation of whatever exists which means that there is no combination of multiple other inventions that show the whole of the claimed invention.

There are three different types of patents that an inventor can apply for: a utility patent protects "process, machine, manufacture, or composition of matter, or any new and useful improvement thereof"; a design patent protects "new, original, and ornamental design for an article of manufacture"; and a plant patent is issued to whomever "invents or discovers and asexually reproduces any distinct and new variety of plant". In addition, a provisional patent application is a one year placeholder for a utility patent application that allows inventors a quick and easy way to get their inventions marked as "patent pending" in advance of making a decision to invest in a formal utility patent application. Patent applications may be filed in other countries within certain limits and timelines.

Utility and plant patents are valid for 20 years from the initial filing date. Maintenance fees have to be paid to the U.S. Patent and Trademark Office ("USPTO") at three set intervals after the issuance of the patent to keep it in force. Design patents are valid for 15 years from the date of issue. Design patents have no maintenance fee requirements. Provisional patent applications are valid for 1 year only.

In many countries any disclosure of an invention would bar any patent application from acceptance. However, in the

Jonathan M. D'Silva is an Assistant Clinical Professor of Law at the Penn State Law School where he is the Director of the Intellectual Property Clinic that is housed at the Happy Valley Launch Box in State College, PA. He is also the Manager and Owner of the law firm MMI Intellectual Property in Erie, PA. He received his B.S. and M.Eng. degrees in Agricultural and Biological Engineering from Cornell University. He received his J.D. degree from the University at Buffalo School of Law. He is a Registered Patent Attorney and admitted to practice law in Pennsylvania, New York, and the District of Columbia. He was born in Kuwait of Indian/Portuguese parents and has been a U.S. citizen since 2005. He and his wife, Melanie have four children.

United States, you have one year from the date of first sale, offer for sale, public use, publication, public disclosure, or non-confidential written disclosure to file a patent application with the USPTO. For any invention that there has not been a public disclosure, you have one year from the date of the first patent application filing with the USPTO to file a patent application in any foreign country's patent office or any regional patent office.

In addition, a patent application may be filed under the Patent Cooperation Treaty ("PCT") through the World Intellectual Property Organization ("WIPO") or one of its many Receiving Offices (which includes the USPTO). A PCT application grants the applicant 30 months from the earliest priority date to file a corresponding patent application in any member country of the PCT (currently 156 countries). It provides a great cost management opportunity to get patent coverage overseas.

Copyrights

Copyrights protect original works of authorship that are fixed in a tangible medium. These works must be independently created (i.e. not copied) even though they may incorporate the works of others. The copyright protection would apply to the newly developed portions of the work. There must be some minimal degree of creativity in the work (titles, slogans, some simple logos, etc. typically do not rise to the level of copyright protection). There can be no copyright in facts, forms, or ideas (but the description of those facts, forms, or ideas, could be copyrighted).

Works of authorship that are subject to copyright include literary works, musical works, dramatic works, pantomimes and choreographic works, pictorial, graphical, or sculptural works, sound recordings, and architectural works. These works must be "fixed" in some tangible medium such as printed on paper, stored in some electronic format, or transmitted wirelessly. Any means of fixing that are now known or later develop would qualify under this limitation.

Copyright comes into existence automatically when an original work is fixed in that tangible medium. The author of the work is the owner of the work, by default, unless there is something in writing that says otherwise. If the author is an employee that creates the work within the scope of their employment, the employer is the author and the owner of the work. Therefore, any independent contractor that is not an employee is considered the owner of any work they create even if they are paid by someone else to do so unless there is something in writing that transfers ownership of the copyright.

Works may be registered at the Copyright Office, but this is not a requirement for copyright to exist. However, if you intend to enforce a copyright in court, registration is required before the court will take up the case. Therefore, it is important to register those works that you intend to enforce. Typically these would be works that form the basis for your sales.

Trademarks/Service Marks

Trademarks and service marks are the names, logos, slogans, etc. that are associated with goods and services in commerce. The law treats trademarks and service marks interchangeably for the most part (except for certain requirements for registration) so the term "trademark" is typically used to refer to both trademarks and service marks.

A trademark is not the name of a business, but the title or name that the relevant purchasing public uses to identify the goods/services that they wish to purchase. A trademark comes into existence automatically when a good/service is sold in commerce. While you may file for a registration application in advance of a sale, registration is not required for a trademark to take effect. At the same time, a registration application will not go into effect until the applicant can prove that a trademark is in actual use – i.e. when you have an actual sale. You may register a trademark at the State level with the Pennsylvania Department of State or at the Federal level with the USPTO. A state registration is generally not recommended.

A trademark may be marked with a ™, but this is not required for a trademark to exist. Similarly, a registered trademark may be marked with a ®, but this is also not required.

Trade Secrets

Trade secrets are those things that you give you an advantage in the marketplace for which you have taken sets to keep a secret. You have to maintain the secret in order for it to be a trade secret. There is no registration or the like to do so. Therefore, these are easy to lose if active steps are not taken to protect them. These include things that don't fall under any other category of Intellectual Property or for which you preparing to file for a patent application.

FARMER DEVELOPED SPECIALIZED EQUIPMENT

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Farmers have a natural inclination to modify the equipment we use or create to meet a particular unmet need. Quite often the new machine may simply remain on the farm where it was first developed, but there may be times when one has to decide if it is something worth sharing or selling to other growers. It seems that in Pennsylvania there is a long tradition of developing machines and then producing them for others. Perhaps because I had witness so many new pieces of equipment developed since I began growing berries and vegetables 45 years ago, there was at least the recognition that there was a pathway to do this. So, when I developed a new cultivating machine for our farm, I had no intention of marketing it, but a Maryland strawberry grower and friend, Phil Johnson, encourage me to build one for him and for others.

There are a number of decisions to be made when taking a creation from the homemade state to a marketable product. One of the early considerations is whether or not it is appropriate to pursuing a patent. Then, who are the people who need the tool and who will produce the product or machine, and how will it will be introduced to those who might benefit from the machine. Figuring out how to price a machine or invention can also be difficult. There is a significant financial risk and also a long-term commitment because at some point people will need repair parts. My first experience with introducing my cultivator to the public was at the Mid-Atlantic Fruit and Vegetable Conference in 2003. There were many people who stopped to look at the cultivator and share input. Coming from a life mostly working on a farm, it was an exhausting experience because I rarely have had to talk to so many people. But, within the first year many changes were made in response to the input from other farmers which also gave it a wider range of applications.

The process of producing a new product requires some universal business practices, and the lessons learned have a broad application. I have gained a new insight and appreciation for the businesses which support agriculture. But some of the universal principles are, developing and maintaining respectful relationships with suppliers; especially paying bills on time in order to have a reliable supply chain and OEM pricing. Communicating with both suppliers and customers is of the utmost importance. This also includes not over promising; giving an accurate description of the strengths and weakness of one's own product.

There is a long list of farmer innovations which have been widely adapted because they were first tested in the actual farm environment where they would be used. They are field tested by the same people who know that the product must work and be an improvement over existing equipment. At the same time, improvements can be made more quickly because the feedback from the actual end user can go directly to the maker. Many of us are familiar with this problem when companies become too large to care about the end user. Whether the farmer developed new piece of equipment is marketed or shared otherwise, there is a benefit to all involved because growers often have a better insight into the way things actually work in the environment of a farm and the need.

John Shenk began growing strawberries as a 4-H project. After graduating from Warren Wilson College near Asheville, NC in 1977 he returned to Lancaster Co. to establish a vegetable and berry farm. In partnership with his wife Linda and son Peter they raise strawberries and raspberries for pick-your-own customers. After berry season, the family sells vegetables at an outdoor market in Phila. As a result of working on some new ways to cultivate and renovate strawberries, Hillside Cultivator Co. LLC began as a side business. Through this project, and membership in the North American Strawberry Growers Assoc., they continue to learn from others about growing berries. Other projects include co-operating with David Douds Ph. D, a USDA soil scientist, in a study of Mycorrhizal Fungi in relation to strawberry yield. The ultimate goal of this farm is to be a good steward of the land and produce healthy food.

TIPS FOR TRAINING YOUR TEAM

Michael Kilpatrick, Growing Farmers

Using work instructions, SOP's, and checklists to clearly communicate and make sure the important work is getting done.

Hiring is harder than ever, and building a focused, driven team is more important than ever. This session covers key Tips for Training Your Team.

What is your mission?
It is essential to ensure that everyone who is working for you is striving for a common goal. If folks are only showing up for their paycheck, you have a problem.

Hire for character, and teach skills.
Hiring starts with understanding what you need. Is it seasonal help to run the corn maze, a worker to keep the greenhouse in top shape, or a new bookkeeper? Each will have different skills. Make a list of the responsibilities they will be taking on, and put together a job description.

Each job description should include these six areas.
1. Your mission and vision
2. Work hours, location, etc.
3. Areas of responsibility
4. Any necessary hard skills (for example: "must know how to weld")
5. Pay range
6. A link to your application form

There are several things to look for, no matter what position is being filled.
1. **Attitude.** Farming is tough, and if, when the going gets rough, they start whining and complaining, no one wins. Always screen for a good attitude.
2. **Trust**. If you can't trust them, they shouldn't be working for you. Period.
3. **Common Sense**. "Figure-it-outness," mental fortitude, the ability to see what needs to be done and "just handle it."
4. **Good Work Ethic**. Sometimes you are looking for someone to pick up apples and put them in bins or pull weeds…but in any case, someone with basic life skills and character is very important to have on your team.

The Application
1. **Avenues** - Start with your email list and social media for best referrals. Other options include Craigslist and Indeed.
2. **Application Process** - Ask questions about the applicant and ask them to post a resume. Folks who refuse to fill out the interview fully are disqualified from the application process. If they can't spend 20 minutes filling out your form, then it is a good indicator that they may not be a good fit for the position.
3. **Interview Process** - This may include a quick check-in call with a team member, then a working interview, followed by an in-depth, in-person interview with your management team if you are hiring for a key position.

Michael Kilpatrick is a farmer, presenter, host, inventor, and online entrepreneur who lives to help entrepreneurs apply business principles and practical, proven solutions to grow their businesses and simplify their lives.
He is the owner of Growing Farmers, an online farmer education platform; host of the top-rated Thriving Farmer Podcast; and host of the Thriving Farmer Summit series, which has been viewed by over a quarter million farmers.
He has managed large farms and businesses, consulted for industry experts worldwide, and spoken at dozens of conferences. Michael believes anyone can build a profitable farm by following the proprietary RIPEN system that he teaches in the Small Farm University, his company's educational platform and community for thriving farmers. Michael lives in an 1890s brick house on his 8-acre urban Farm on Central in Southwest Ohio with his wife and 3 kids.

FARM MARKET STAFF TRAINING

Onboarding

First impressions matter. Create a good flow, from the date of acceptance through the first 90 days, that sets a solid foundation for engagement. This process may include an offer letter, agreement, farm employee manual, and a link to the food safety manual. Be sure these are read and signed before their first day of work. Include a first-day tour, training, and 30-60-90-day reviews.

Team Management

Management is the day-to-day process of maintaining an effective and productive team. Here are nine team management tips.

1. **Be sure everyone is on the same page.** Morning meetings are essential (quick five-minute check-ins) and weekly in-depth team meetings.
2. **Have a clear line of command.** To prevent frustration, everyone should have one boss.
3. **Coach, don't fix it.** Give your team members space to solve problems.
4. **Manage by walking around.** Your people need to see you.
5. **Show appreciation.** People need to feel valued.
6. **What you value, they will also value. Model your values.**
7. **Document, document, document.** Know your numbers and metrics. Set goals with your team.
8. **Know the power of your team.** A good team is unstoppable.
9. **Release with dignity.** Three reasons for release: (1) Incompetence (and only after documented retraining has occurred), (2) Betrayal of trust - lying, stealing, gossip, or uncouth behavior, or (3) Repeatedly being late. Hire slow, fire fast.

The labor market and hiring pool is challenging right now. These tips will help you thrive in these challenging times!

AGRITOURISM ACTIVITIES FROM A LOCAL MUNICIPAL PERSPECTIVE

Peter Wulfhorst AICP, Extension Educator, Penn State Extension

The Pennsylvania Municipalities Planning Code or MPC is the state law that enables Pennsylvania local governments (townships, boroughs, cities, counties) to plan and regulate land use activities within their respective boundaries.

A purpose of the Act is 'To ensure that municipalities enact zoning ordinances that facilitate the present and future economic vitality of existing agricultural operations in this Commonwealth and do not prevent or impede the owner or operator's need to change or expand their operations in the future in order to remain viable".

Zoning is a land use regulation tool in the PA MPC that Pennsylvania municipalities. Zoning is based on the concept of Police Power which protect and promote public health, public safety, morals and general welfare. Zoning is Community Wide and divides the community into Zoning Districts.

Why is Zoning Important

- Promote Organized Growth
- Maintain health, welfare and safety of the community
- Promote energy conservation using planning practices
- Protect agricultural land, natural resources and historic land
- Protect agricultural operations without impeding the need for future growth

Local Municipalities (Counties, Cities, Townships, Boroughs) adopt Zoning Ordinances.
Who Administers Local Zoning Ordinances

- Governing Body
- Zoning Officer
- Zoning Hearing Board
- Planning Commission

Subdivision/Land Development (SALDO) regulations is another land use regulation under the PA MPC and "Agricultural Development" might fall under the SALDO regulations.

How to Avoid Problems with Zoning

- Understand How the New Operation Uses the Land
- Contact Your Local Zoning Office for Additional Information
- Know When to Consult an Attorney

Things to Consider

Specific issues that Agri-Tourism operations that have dealt with local municipal land use regulations will be shared.

Peter Wulfhorst is an Economic and Community Development with Penn State Extension in Pike County since 1999.
Peter has extensive experience in land use and comprehensive planning having worked prior to Penn State Extension for 12 years with the Pike County planning department. Peter's other experience includes assisting communities & organizations in developing strategic plans, conducting grant-writing workshops & volunteer management workshops, overseeing a Penn State Extension land use webinar series and assisting homeowners with their private water supply concerns.
Peter represents Pike County on a Local Development District in Northeastern Pennsylvania.
Peter is a member of the American Institute of Certified Planners.

HOW TO PICK WHICH ACTIVITIES ARE RIGHT FOR YOU AND YOUR CUSTOMERS?

Specifically, our Partnerships with Community Groups

Lisa Godfrey
Godfrey's Farm, 370 Leager Road, Sudlersville MD 21668

Our farm is in a rural area – 30 minutes from anywhere; and 1 or 1 ½ hours from everywhere. The main draw of the retail business is pick-your-own – blueberries, strawberries, and cut flowers. In the last couple of years, we have added blackberries and sunflowers. We also have you-pick peaches when the crop cooperates.

We currently host three festivals each season as well as a Home School Strawberry Day and hosting several local elementary school field trips.

While I would consider field trips and Home School Day community outreach. I will focus on the Sudlersville Peach Festival and the Blueberry Boogie 5K here, because these events include a partnership with community groups.

Sudlersville Peach Festival

The Sudlersville Volunteer Fire company approached us 10 years ago, asking if we would be interested in co-hosting a peach festival. At that time, we had never done a festival, but having always wanted to do one, we quickly agreed. We divided responsibilities, met every couple of weeks, and invited the local churches, businesses, and other community groups to participate. We were adamant that we wanted a "true" community event, inviting local hand crafters, breweries, and food vendors. The local churches, Lion's Club, Ruritan Club, etc. have never paid a vendor fee. They have grown to plan and depend on the money they raise at the peach festival.

Somehow, we managed to attract a lot of people to the event. The first year was much bigger than any of us expected – running out of food, traffic jams, etc. But we had all caught the "festival bug" and have worked every year to add to the event, while smoothing out whatever wrinkles we can. Last year, we added Fireworks on Friday night, and next year we have a parade in the plans. As a small town, I believe this event has been a great addition. Maybe, we could say it has put us on the map?

Blueberry Boogie 5K

We have done the Blueberry Boogie for two years. In contrast to the peach festival, this event was something that we created alone. Having always wanted to host a race, I approached a local race director with my plan. He said that I needed a charitable cause. So, we brainstormed and decided the Maryland Food Bank would be a great fit for our business. We already had a working relationship with the organization, as we donated sweet corn on a regular basis with their farm to table program, and I had a contact. We went from there.

For last year's race, I chose The Benedictine School, a local campus providing comprehensive services for children and adults with developmental and intellectual disabilities from Maryland and adjoining states. I hoped they might offer more help recruiting sponsors as well as race participants. We raised $15,000 for this year's race and had just over 200 participants.

Lisa Godfrey along with her husband, Tom, own and operate Godfrey's Farm in Sudlersville Maryland. They grow a variety of hand-harvested fruits and vegetables during the spring and summer months. While Tom is primarily responsible for growing and production, Lisa focuses on sales, both wholesale and retail. Born in Tennessee, Lisa graduated with a degree in computer science from Colorado State University and after working in that field for several years, moved to Maryland where Tom was growing and selling vegetables to local roadside stands and grocery stores. They have twin daughters Jane and Emily, who are currently juniors at CSU.

HOW LOW TUNNELS IMPROVE EFFECTIVENESS OF STRAWBERRY BIOCONTROLS

Samantha Willden[1], Todd Ugine, and Gregory Loeb
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Plastic selection is an important choice growers make to manipulate the growing environment under tunnels. Among the many physical characteristics that plastics have, UV-selectively is an essential feature that can improve the efficacy of many pesticides and biopesticides. By blocking harmful UV radiation, these products break down more slowly in the field and are biologically active for longer. However, most low tunnel strawberry growers use a standard plastic that is UV-transparent due to cost and convenience compared to other plastics. There is an opportunity to encourage the development of alternative plastics tailored to low tunnel crops that includes UV-selectivity.

UV-selective films improve efficacy of biopesticides and standard insecticides against tarnished plant bug: Lab and field assays determined that low plastics that blocked the most UV radiation improved efficacy of Mycotrol (active ingredient of Beauveria bassiana, an insect-killing fungus) and Assail (active ingredient acetamiprid) against tarnished plant bug. For Assail, this effect was associated with fewer naturally occurring tarnished plant bug in strawberry and fewer fruit damaged by tarnished plant bug. Although Mycotrol efficacy was improved under UV-blocking tunnels, we saw little protection against tarnished plant bug in the field using this product. There was no negative effect of UV-limitation on fruit yield for control plots that did not receive either product.

Implications: UV blocking plastics significantly improved the efficacy of two types of products labeled for tarnished plant bug on strawberry. Although the improved efficacy of Mycotrol weakly translated into better fruit protection, we feel this product would be more effective on a larger strawberry site where recolonization by tarnished plant bug is lower (i.e., fewer entry points). Mycotrol, and other products containing entomopathogens, take several days to kill targets and constant reinfestation by uninfected individuals may dilute any product effects. Assail, in comparison, is fast acting and more field stable. This study also indicates that product labels should be tailored to UV-limited tunnel environments where products are more biologically active, to reduce harmful exposure to farm workers and non-target organisms. One downside of UV-blocking plastics is that they are generally thicker, less flexible, and more expensive than standard films used for low tunnel strawberry. Therefore, this research reveals a need for UV-selective, cheaper, and easy to manipulate plastics for low tunnel strawberry production.

Dr. Samantha Willden is originally from the deserts of southern Utah. She received her B.S. and M.S. degrees at Utah State University where she was exposed to insects, and their important role in agricultural systems. Dr. Willden moved to upstate New York to gain more experience in specialty crop production and pest management under the supervision of Dr. Gregory Loeb. She received her PhD in Entomology from Cornell University in 2022. She is currently a postdoctoral researcher at Purdue University working with Dr. Laura Ingwell on specialty crop production under high tunnels. Her primary work is focused on biological control and developing new tools for pest management on urban farms.

WHAT WE'VE LEARNED ABOUT GROWING BERRIES OVER THE YEARS

Michael Groszkiewicz, Mason Farms

- Field selection and preparation
- Select your best fields for strawberry production
- Well drained
- Good fertility
- Eliminate perennial weeds before planting
- The year or two before planting

Morning shading of the field will extend the time needed for frost control in the spring, it takes time for the sun to get above those trees. We fumigate our strawberry ground, we have seen a significant difference in the size of the plants on treated and untreated ground.

Planting

When we started planting strawberries we used a one row Mechanical transplanter and followed up with a cub tractor to side dress the new planting. The strawberry crown grows from the top, so you need to plant them pretty deep. We are happy if we can barely see the top of the plant after planting. It does make it harder to fill in skips. We now use a 3 row Mechanical transplanter to plant our strawberries. We plant on 42" rows, and between 12 and 15 inches between the plants. We used to use the fertilizer hoppers on the planter, but they were rusting out and applied too much fertilizer and burned the roots. We now broadcast a custom blend on the field before planting. We plant as early as possible in the spring. We have tried planting June bearing and day neutral berries on plastic. We were not successful. The raised beds caused drainage problems and more disease problems in the day neutral. All of our strawberries are on matted row. We prefer rye straw but have used wheat and oat straw. We started out planting solid across the field, then every ice we need to work the strawberries we needed to move the irrigation pipe. We then began skipping 1 row every 60 feet to leave the pipe in. Now we plant sections, 15 rows and leave a space equal to 3 rows for the pipe and our sprayer to drive in. This way we damage less strawberries when spraying them.

Mike Groszkiewicz, farm manager Mason Farms, Penn State B.S. Agricultural Mechanization 1989, Minor Business/Liberal Arts. Penn State Master of Agriculture Agricultural Mechanization 1992. One daughter, three grandchildren. Current Grand Knight of my council of the Knights of Columbus. Father was a shop worker and truck farmer. Mom helped grandpa in his business and raised us 5 kids. Began working at Mason Farms when I was 13, picking strawberries and other vegetables. John wanted to borrow my dad's Cub tractor, and I say I came with the tractor. Now I oversee equipment maintenance, irrigation, planting, crop protection, field preparation, ordering supplies for the farm.

We used to use Small square bales at 250 bales per acre. With the vast acreage of strawberries we grow now, we use large round bales (5x6) and aim for 10 to 12 per acre. As soon as the strawberries are dormant we apply our fall weed sprays then begin covering the berries. In the spring, as soon as we see leaves beginning to emerge we begin taking the straw off the berries. Years ago, it was done with pitchforks, now we use a hydraulic strawberry rake. We focus on the early varieties then move to the mid season and finally the late season berries.

For disease control, we use conventional and bio pesticides. During the harvest season we chlorinate the irrigation water. Harvesting use to be local teens. This past year was our second using H2A workers. This year we had 19 for strawberry season. We use to pick into wood quarts, we now use fiber quarts, on rainy days we will use plastic quarts. The pickers fill the quarts, pace them in a flat and bring them to the end of the field. Renovation begins as soon as possible after harvest. We weed spray, spread fertilizer, mow, subsoil, and then use a multivator to narrow the rows. We use to do one row at a time, now we do three rows at a time. Late summer early fall we switch to a danish tine cultivator. We spray for diseases in the fall to keep the plants healthy.

WHERE STRAWBERRY ANTHRACNOSE HIDES

Leah Fronk[1], Kathy Demchak[2], Dr. Sara May[3], Dr. Richard Marini[2], Lauren Bloom3
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Anthracnose, caused by fungi in the *Colletotrichum acutatum* and *C. gleosporiodes* species complexes, is responsible for significant economic losses in strawberry production worldwide in nursery and farm environments. Symptoms can be seen on fruit, petioles, leaves, and crowns. The presence of diseases caused by *Colletotrichum* in nursery transplants is of great concern to strawberry growers. The pathogen is often present without symptoms in transplants and may be further spread to soil, equipment, and other plants by water-splashed spores. It is also possible that some spores may be wind-blown into the planting from the surrounding environment. *Colletotrichum* can remain asymptomatic on strawberry and other plant material for some time until it causes lesions on fruit or other plant parts.

Since strawberry is often managed as a perennial crop or in fields with minimal crop rotation, the presence of weeds in strawberry fields was suspected to be another source of the disease. In other studies, *Colletotrichum* of the same species infecting strawberries has been found on various weed species in strawberry fields. Additionally, at least one study has shown that the application of certain herbicides increased severity of *Colletotrichum* in a strawberry planting. Wounding plants is a technique pathologists use to induce sporulation, and these herbicides may have had a similar effect.

Efforts and Findings
This study surveyed weed species in PA strawberry fields with active anthracnose infections during 2021 and 2022. Multiple plants of each species were collected. Of the 15 weed species collected, two were grasses (yellow foxtail, common oat), one was a sedge (yellow nutsedge), and 12 were broadleaves (redroot pigweed, dandelion, black nightshade, yellow woodsorrel, white clover, common ragweed, broadleaf dock, Pennsylvania smartweed, marestail, field bindweed, common lambsquarters, and broadleaf plantain). Eight of these weeds have perennial life cycles, and seven are considered annuals. Four weed species were collected during both growing seasons: broadleaf dock, dandelion, black nightshade, and yellow nutsedge.

Each weed species, though not every plant collected, showed the presence of *Colletotrichum*. Dock, nightshade and nutsedge consistently tested positive for *Colletotrichum* infection. As of this printing, the predominant species identified in weeds was found to be *C. nymphaeae*, which is part of the *C. acutatum* complex. According to research performed by Dr. M. Hu at the University of Maryland, the *C. acutatum* complex was responsible for 100% of anthracnose fruit rot, and 49% of anthracnose crown rot in a Mid-Atlantic survey of infected plants.

To further test the ability of the fungi obtained from the weeds to infect strawberries, fruit assays were completed. In this process, strawberry fruit are surface sterilized and then inoculated with a spore solution made from mycelium grown from the weed samples. A fungal sample from each weed species, confirmed to be *Colletotrichum*, was used. The spore solution from the weeds was successful in infecting the strawberry fruit in almost every instance.

Strawberry growers should be aware that allowing weeds to persist in strawberry fields can allow *Colletotrichum* to hide. Determining which was infected first – the weeds or strawberry plants – is not known, but the fact that *Colletotrichum nymphaeae* could persist on weeds means that weed control takes on added importance. Much more work will need to be done, but for now, we have more answers on how clean plants may first become infected in nursery or grower fields.

Cultural Controls for Anthracnose
Whether you see anthracnose or not on your plants, it is likely lurking. It will wait for warm, wet weather to begin showing symptoms. Reduce the risk of anthracnose infection by removing as much cull fruit from the field as possible. Avoid picking plants when foliage or fruit is wet. Prevention of weeds reduces hosts and also maximizes air

flow. Preventing weeds may be a better approach than burning them down after they grow, and tilling weeds in may be better than allowing them to lie on the soil surface. When planting, do not overcrowd your rows. Overcrowding plants results in it taking longer for the plant to dry out from heavy dew and/or rain, and anthracnose sporulation is more likely with a leaf wetness period of 7 hours or longer.

Chemical Controls for Anthracnose

Current fungicide recommendations for anthracnose disease management take into consideration resistance management. Knowing the mode of action and risk of resistance for each product applied is very important. Use single-site fungicides only when necessary. Multi-site fungicides (captan or thiram, depending on targeted diseases) should be the backbone of your spray program; captan is more effective for anthracnose, whereas thiram is more effective for botrytis. During dry spells, these products by themselves may be all that is needed, but when disease pressure is higher (during wet weather), add single site active ingredient(s). If a single-site fungicide is warranted, effective materials that could be added which would also control gray mold include Switch (group 9 + 12), Miravis Prime (group 7 + 12), or Luna Flex (group 7 + 3). If anthracnose is the only disease being targeted and category 11 fungicides have not lost efficacy on your farm, one application of a fungicide containing a category 11 active ingredient (Cabrio, Pristine, Quadris Top or Quilt Xcel) may be made. If category 11 fungicides have lost efficacy, other choices for anthracnose control would be Inspire Super (Group 3 + 9) or Tilt (group 3). Traditionally, the active ingredients in these products had not been considered effective for anthracnose, though recent research at the Univ. of Maryland has shown otherwise. Be aware that not all active ingredients in group 3 have efficacy on anthracnose.

To manage resistance development, make only one application of a category 11 fungicide per year, or a maximum of 2 applications of other single-site fungicides. Apply fungicides before rain events so the product becomes affixed to the leaf surface before rain occurs.

For more information on resistance issues and fungicide recommendations, see the web article "Strategies for Effective Management of Botrytis and Anthracnose Fruit Rot in Strawberries", which summarizes current disease management recommendations, including a discussion of resistance issues and fungicide use: https://extension.psu.edu/strategies-for-effective-management-of-botrytis-and-anthracnose-fruit-rot-in-strawberries

Please note that any discussion of fungicides is superseded by information on the fungicide label.

Thanks to the Pennsylvania Vegetable Growers Association for providing the funding for this work, and Dr. Mengjun Hu at the University of Maryland for further collaborations related to this work.

OVERVIEW OF A PROJECT TO DEVELOP NEW PROPAGATION STRATEGIES FOR THE STRAWBERRY INDUSTRY

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The capacity of US open-field strawberry nurseries to develop clean plant material is crucial to the $2.8 billion strawberry fruit production industry. Unfortunately, the strawberry nursery industry is highly complex and faces several major challenges: 1. Propagation material can be a symptomless carrier of plant pathogens. 2. Nurseries are often dependent on Methyl Bromide (MB) for soil disinfestation 3. Technology used by the industry is impacted by environmental factors. 4. The current multi-year and multi-location propagation processes are costly. These challenges often lead to growers in the Mid-Atlantic region having limited variety selection from nurseries, problems with receiving plants late for appropriate planting windows and discovering disease outbreaks after planting.

To address these challenges a team has developed a $5.3M USDA-NIFA SCRI-sponsored multi-state project (Development and integration of next-generation propagation strategies to increase the resilience of the US strawberry supply chain. Grant No.: 2021-51181-35857). The aim of this project is to produce additional tools for the strawberry industry to produce cleaner plants in enclosed environments. This 4-year project started in November 2021 and consists of 19 scientists at 12 universities across the country. The scientists are experts in their fields of controlled environments, plant physiology, genetics, plant breeding, economics, and production. Collectively the scientists are tasked with developing a faster and cleaner way of developing strawberry transplants in North America. An important component of this project is the collaboration with more than 20 industry partners in the US, Canada, and Europe.

The project objectives include:

1: Characterization of strawberry mother plant physiological responses to the environment.
2: Development of environmental protocols for transplant establishment, conditioning and long-term storage.
3: Development of a genetic tool to elucidate strawberry runnering and flowering potential of genotypes, based on phenotypic responses to environmental treatments.
4: Determine expected economic costs/returns to industry of adopting developed techniques, and estimate the economic impact of adoption on the US strawberry supply chain.
5: Translation and integration of new propagation systems with industry partners.
6: Development of services and products, extension and outreach activities to industry and public stakeholders.

The project will occur in two phases: Phase one is - Research and Discovery (Obj. 1, 2, 3 and 4); Phase 2 - Field Evaluations and Education (Obj. 5 and 6 mostly). Obj. 4 will be active in phase 2 as well.

The goal is to develop, validate and adopt controlled environment (CE) technology for the propagation and conditioning of strawberry plants in the US. The aim to develop new tools to propagate strawberries in growth chambers and to optimize greenhouse as well as in open-field nursery propagation.

Throughout the project the progress of the work will be communicated to researchers, industry and the general public. A website, field days, a news blog, webinars, etc. will be used to educate everyone involved in the strawberry supply chain to ensure adoption of the knowledge and technology developed.

Peter Nitzsche is an Agricultural Agent with Rutgers Cooperative Extension of Morris County, New Jersey. He conducts educational programs in commercial vegetable and small fruit production and marketing. He has a B.S. degree in Plant Science and an M.S. degree in Horticulture from Rutgers the State University. He has conducted research and extension on a wide range of crops and has focused recently on tomatoes, strawberries, and the evaluation of unique ethnic and specialty crops.

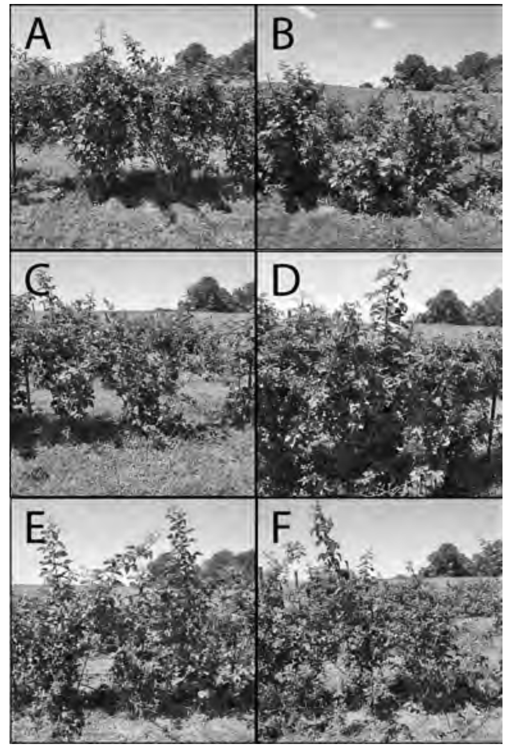
This project is led by Dr. Mark Hoffmann (project director) and Drs. Ricardo Hernández and Gina Fernandez (co-directors of the project) at NCSU. Additional researchers are from the USDA-ARS Service in Ohio, Virginia Tech, Rutgers University, University of Maryland, The Ohio State University, Cornell University, University of Florida, Purdue University, UC Davis, UC ANR, and the strawberry center at Cal Poly San Luis Obispo.

More information about the project can be found at the: Strawberry PIP-CAP SCRI (PIP standing for "Precise Indoor Propagation") website: https://strawberries-pip.cals.ncsu.edu/

PERFORMANCE OF BLACKBERRY VARIETIES

Alan Leslie
Univ. of Maryland

Blackberries are an attractive alternative crop for many fruit and vegetable farmers in the Mid-Atlantic, and present an opportunity to add diversity to pick-your-own, direct sale, or wholesale operations. In general, blackberries are well adapted to growing conditions throughout the Mid-Atlantic, but newer variety releases from state breeding programs in Arkansas and North Carolina have yet to be thoroughly tested in this area. In collaboration with the Southern Maryland Agricultural Development Commission, we established a variety trial, testing six newer varieties at the Central Maryland Research and Education Center in Upper Marlboro, MD. The blackberry varieties included in the trial are Arapaho, Freedom, Natchez, Osage, Ouachita, and Von (Fig. 1). All varieties are thornless, floricane-fruiting types, with the exception of Freedom, which is a thornless, primocane-fruiting variety. Floricane varieties produce fruit on the second-year growth of the plant, which results in earlier fruit production and typically a short fruiting period with high yields. These varieties require overwintering of the first-year growth, and can be sensitive to extreme winter temperatures. Primocane varieties develop fruit on the first-year growth, and therefore typically do not mature until late summer or early fall, which can extend the harvest season. Primocane varieties do not rely on winter hardiness of first-year canes, and therefore may be more resilient to abnormally cold winters. For this trial, we retained the first-year growth of Freedom plants to measure both floricane and primocane production in a single season. However, future reports will focus on primocane production in this variety.



The variety trial was initially established in the spring of 2018, with four replicates of each variety planted in a randomized complete block design. Each replicate contained three plants of that specific cultivar, each spaced 3 feet apart. For the initial two years, data were collected on plant vigor and survival, with 2020 being the first year that yield data were collected. Fertilizers and protective fungicides were applied according to production guide recommendations. Weeds were controlled with herbicide application in early summer and mowing between trellised rows. A single application of lambda-cyhalothrin (Warrior II) was made to suppress insect pests, but regular insecticide applications were not made through the season. Fruit loss to insect damage was substantial, and yield values are expected to be higher with better insect scouting and spraying. Therefore, this yield data mainly highlight differences in yield between varieties, and may not necessarily represent the actual yield potential for any individual variety. The primary insect pests observed this year were spotted wing drosophila (Drosophila suzukii), potato leafhopper (Empoasca fabae), and brown marmorated stink bug (Halyomorpha halys). The 2021 harvest year saw a mass emergence of periodical cicadas, which caused direct damage to the floricanes where female cicadas laid eggs inside the stems. This likely reduced yield significantly during that harvest year.

Dr. Alan Leslie got his Ph.D. from the University of Maryland studying invertebrate communities in agricultural drainage ditches on Maryland's Eastern Shore with Dr. Bill Lamp. Alan went on to work as a postdoc with Dr. Cerruti Hooks at UMD studying weed management and conservation biological control of insect pests in grain and vegetable systems. Alan is currently working as an Extension Educator in Agriculture and Food Systems with University of Maryland Extension in Charles County. His extension programming incorporates sustainable approaches to insect and weed pests in agronomic and vegetable crops.

Assessments were made of the vegetative growth and relative vigor of each blackberry variety on June 26, prior to initiation of berry harvest (Table 1). Ripe berries were picked weekly between early July and early August and weighed to determine yield per replicate. Because replicates had uneven plant survival, we then divided the yield values by the number of surviving plants to present yield on a per-plant basis as well as a per-plot basis (Table 1). A subsample of harvested berries were counted and weighed separately to determine average berry size. Yield totals for the first harvest season are summarized in Table 1, with Arapaho, Von, and Osage producing the highest yield on a per-plant basis during the harvest period.

Table 1. Summary of plant performance measures in 2020.

Variety	Survival (%)	Floricane (ft)	Primocane (#)	Vigor (scale 1-5)	Yield (lbs/ plant)	Yield (lbs/ plot)
Arapaho	75.0	4.25	1.7	2.9	2.88	6.39
Freedom	75.0	1.75	4.1	1.5	0.08	0.22
Natchez	66.7	3.12	1.2	1.3	0.29	0.53
Osage	100	6.50	4.2	4.4	1.88	5.65
Ouachita	91.7	4.75	3.4	3.1	1.18	3.38
Von	100	4.13	3.9	2.8	2.13	6.40

However, differences between varieties were not statistically significant, because of high variation in yield within each variety. The first year of harvest showed slight differences in timing of fruit production, with Osage peaking earliest in the season (Jul 20), followed by Arapaho and Von the following week (Jul 27). Ouachita had a less pronounced peak, and had similar yields through two weeks of harvest (Jul 20 - Jul 27). The 2021 and 2022 harvests were more synchronized across the different varieties. Figure 3 shows the mean berry size by variety. Arapaho produced the highest yield and the largest berries, while Von and Osage, which produced the second and third highest yields, had the smallest berries on average. Early observations indicate that varieties Osage, Von, and Ouachita are good candidates for commercial production in Maryland. Arapaho had the highest per-plant production, but had the second lowest survival through establishment. One other interesting note was the overall poor performance of Natchez, with the lowest survival (66.7%) and the lowest per-plant yield among floricane varieties. Previous trials at CMREC have had good success with this variety, and possible reasons for the poor survival of this variety are unknown. Natchez and Freedom were relatively poor performers throughout the trial. Yield from Freedom was assessed from canes managed to produce floricane fruit, but the yield from these canes were not on par with the other floricane varieties. The overall goal is to provide objective assessment of the quality of these different blackberry varieties for Mid-Atlantic farmers.

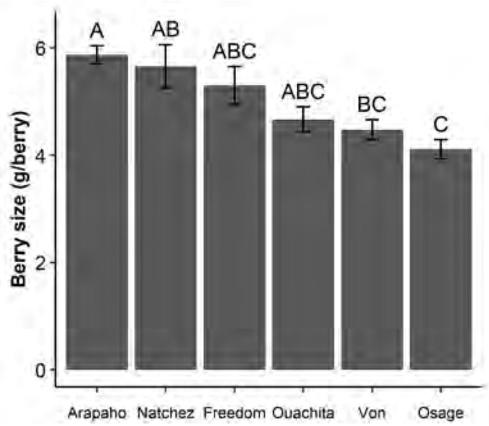


Figure 3. Mean berry size of each variety measured in 2020.

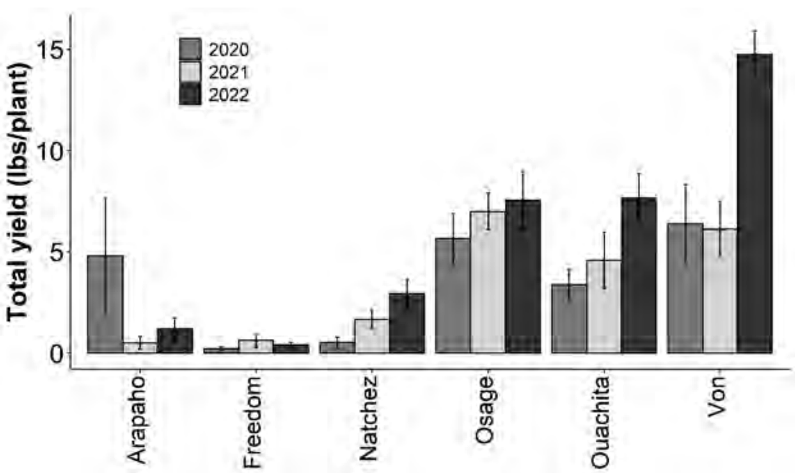


Figure 4. Average total yield of each variety on a per plant basis over three years of harvest.

HERBICIDES FOR BERRIES AND THEIR STRATEGIC USES

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Proceedings Summary

In order to develop a comprehensive weed control strategy for small fruits, an investment in understanding herbicide chemistry is required. In recent years a number of new herbicides have been labeled for use in small fruits. This introduction of new herbicides for small fruits makes developing a herbicide program more challenging. However, the goal of weed free fruit production is now very obtainable. Establishment of fruit is the most critical time for a successful weed control program. The simple economics of fruit production requires minimizing weed competition during the establishment years, leading to early fruiting potential, and quickly achieving maximize small fruit production. Herbicides need to be selected carefully at establishment that are least likely to cause injury to the young fruit plants, and used with strategies to avoid green tissue contact. Preemergent grass and small seeded broadleaf weed control herbicides are especially important during establishment, as grasses and broadleaf weeds will out compete young fruit for nutrients and water. As the small fruit plantings becomes established, with developed root systems and crowns, the chance for herbicide injury generally lessens, allowing a number of herbicides to be added to the spray program. This allows a number of new PPO herbicides labeled for small fruit to be strategically implemented for control of some of the toughest broadleaf weeds. If the fruit acreage is too large for hand detail spraying, then it is imperative that the sprayer is set-up to deliver very controlled directed spray applications. Generally, hand spraying or a fixed boom from an ATV will prove to be an excellent tool for strategically applying the spray directly to the weeds and soil at the plant crown. The use of drift guard nozzles and drift prevention adjuvants, will also decrease the likelihood of small droplet swirl onto the leaves and green tissue of the small fruit. There are a number of considerations related to herbicide chemistry that often make the difference between a successful weed control program and failure. It is important to understand soil type, soil pH, quality of the spray water used during application. The specific herbicide chemistry also needs to be fully understood, such as water solubility, KOC, degradation pathway and soil half-life. Understanding the chemical properties of each herbicide will support the proper label usage as a burndown, preemergent or postemergent product, see Table 1: Common Fruit Herbicides.

Ronald David Myers has been a lifelong resident of Anne Arundel County, and currently is the agricultural Extension Educator for both Anne Arundel and Prince George's Counties. Prior to assuming the University of Maryland Extension position in December 1997, Mr. Myers was the Agronomist/Crops Master for the U.S. Naval Academy Dairy Farm, where he was employed from 1980 to 1997. While working at the Naval Academy Dairy, Mr. Myers earned in 1983 a BS degree in Agronomy, Crop Science and in 1996 a MS degree in Agronomy, Weed Science from the University of Maryland. His Extension responsibilities include all field crop and livestock agriculture with an emphasis on fruit and vegetable production and marketing. Mr. Myers conducts fruit and vegetable research trials at the University of Maryland Upper Marlboro Research and Education Center, and in 2022 created the Anne Arundel Extension Urban farming Research Clinic at the former Naval Academy Dairy Farm property.

Table 1. Common Fruit Herbicides

Common Fruit Herbicides*

Herbicide	Low Rate	HRAC	Application Timing and Activity	Koc ml/g	Water Solubility mg/L	Soil Half-Life Avg Days	Application Notes
Gramoxone paraquat	1.0 qts	22	Burndown	1,000,000	620,000	1000	Directed Spray, Latex Trunks, Wraps 1-3 Years
Roundup glyphosate	1.0 qts	9	Burndown	24,000	15,700	47	Shielded, Directed Spray, Latex Trunks, Wraps 1-3 Years
Rely glufosinate	22.0 ozs	10	Burndown	100	1,370,000	7	Shielded, Directed Spray, Latex Trunks, Wraps 1-3 Years
Devrinol napropamide	4.0 lbs	15	Preemerge	700	73	70	Spring, Early Summer, 35-day PHI
Surflan oryzalin	2.0 qts	3	Preemerge	600	2.6	20	Spring or Summer, Surflan 0-day PHI
Prowl pendimethalin	2.0 qts	3	Preemerge	17,200	0.275	44	Spring, Prowl 60-day PHI
Karmax diuoron	1.0 lbs	7	Preemerge	480	42	90	Fall or Spring Dormant, 3-yr Established
Sinbar terbacil	4.0 ozs	5	Preemerge	55	710	120	Fall Dormant, 1-yr Established
Kerb pronamide	2.0 lbs	15	Preemerge	840	15	35	Fall Dormant, 1-yr Established
Princep simazine	1.0 qts	5	Preemerge	130	2	80	Spring Dormant, Avoid >7 pH Soils, 3-yr Established
Alion indazaflam	3.5 ozs	29	Preemerge	496	dispersible	—	Fall or Spring Dormant, Directed Spray, 3-yr Established
Casoron dichlobenil	100 lbs	20	Preemerge	—	dispersible	—	Granular Applied Incorporated, 4-weeks Post Transplanting
Solicam norflurazon	2.5 lbs	12	Pre & Post	700	28	112	Spring or Fall, 1-yr Established
Chateau flumioxazin	12.0 ozs	14	Pre & Post	—	1.79	14	Broadleaves, After Harvest to Bud Swell
Goal oxyfluorfen	1.0 qts	14	Pre & Post	100,000	0.1	30	Broadleaves, After Harvest to Bud Swell
2,4-D	1.0 qts	4	Pre & Post	62	—	14	Dormant Only, Avoid Temps Above 85° for 3-Days
Matrix rimsulfuron	4.0 ozs	2	Pre & Post	—	7300	2	Spring, 1-Yr Established, Mixed Weeds
Zeus Prime XC sulfentrazone + carfentrazone	7.5 ozs	14	Pre & Post	mobile	dispersible	—	Shielded Spray, 3-14 day PHI, Avoid >7 pH soil, 2-yr Established
Aim carfentrazone	2.0 ozs	14	Post	750	12,000	0.1	Broadleaves, Directed Spray, 0-3-day PHI
Venue pyraflufen	2.0 ozs	14	Post	2090	0.5	3	Broadleaves, Directed Spray, 0-3-day PHI

*** Consult label for specific fruit applications.**

R. D. Myers 2022

BRAMBLE VIRUSES: RESULTS OF A PA SURVEY AND THEIR MANAGEMENT

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Many different bramble viruses exist, but little had been known about which are currently common in the Mid-Atlantic region. Major nursery suppliers have worked to eliminate viruses from planting stock through using tissue culture and virus indexing, so whether the same viruses that were common decades ago are still common has been unclear. Further, the availability of molecular techniques now brings more certainty to virus identification, plus new viruses have been identified that previously could not be detected.

In 2018, commercial red and black raspberry and blackberry plantings and wild black and red raspberries and blackberries were sampled across the state in a coordinated effort with extension educators and growers. Plants were sampled from 18 commercial farm plantings and 19 wild patches in a total of 15 counties, usually but not always focusing on plant material that looked like it could be infected. Samples were assembled and coded, and overnighted to Dr. Bob Martin at the USDA Horticultural Crops Research Unit in Corvallis, Oregon. There, viruses present were determined using ELISA and/or RT-PCR testing depending on the virus. In total, 159 samples were submitted and tested for 24 different viruses, one phytoplasma (a type of bacteria) and a second bacteria of concern. There could have been additional viruses present for which there are no tests developed yet which would have remained undetected.

Usually having only one virus present in a plant results in few or mild symptoms; i.e, the plant continues to be productive. The main concern then becomes that the virus can be vectored (moved) to other plants, and the presence of two or more viruses in a plant can result in more serious symptoms such as reduced vigor or crumbly berries, and in a few documented cases elsewhere with particularly troublesome viruses, plant death.

Symptoms Seen

Symptoms typical of viruses were seen (ringspots, leaf blotchiness, crinkling or uneven leaf growth), but these symptoms were also sometimes present where viruses were not detectable, indicating either the presence of an unidentified virus(es) or another issue (herbicide, environmental, or insect injury) that was mistaken for a virus. Identical symptoms can show up on plants that have different viruses, and so symptoms alone are not a reliable way to diagnose which virus(es) may be present.

Viruses Found

Some of the viruses found were part of virus complexes including raspberry mosaic disease, raspberry crumbly fruit, and blackberry yellow vein disease. Nematode-transmitted viruses were also detected and a relatively uncommon one was as well. Overall, 54 (34%) of the samples were positive for having at least one virus, but importantly, only 11 samples (7%) tested positive for two or more viruses, and only 1 sample had 3.

By far the virus most commonly found was blackberry chorotic ringspot virus (in 42 samples or 26% of samples collected). It can also infect apples. When found alone in a plant, symptoms are mild. It is transmitted in pollen, which means that it can be transported long distances by wind. It has shown up quickly in new plantings of virus-indexed (i.e., thought to be virus-free) plants in the South, which means that transmission occurred shortly after planting.

The second most frequently found virus was black raspberry necrosis virus (11 samples, 7%), which is a bit of a misnomer, since alone it doesn't cause necrosis (i.e., dead tissue). This virus is aphid-transmitted and widely distributed world-wide. Interestingly, plants infected with this virus emit at least two volatiles in higher concentrations that make them more attractive to aphids. It can take as little as two minutes of feeding for aphids to transmit a virus.

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.

Other viruses found were one of two unnamed viruses in 6 samples, raspberry bushy dwarf virus in 2 samples and in one sample each, tomato ringspot virus, apple mosaic virus, and tomato black ring virus. Raspberry bushy dwarf virus is pollen-borne (like blackberry chlorotic ringspot virus) and can cause crumbly berries. The incidence of tomato ringspot virus was much lower than expected considering that it is common in multiple species of cultivated plants and broadleaf weeds. It is vectored by dagger nematodes and can cause reduced vigor, cane length, and yields. Apple mosaic virus affects at least 65 different species of plants including tree fruit, berries, forest trees, and weeds. The vector isn't known, though it is likely an insect of some sort. Tomato black ring virus is nematode-vectored.

Differences among Plant Types

By far, cultivated black raspberries were the group with the highest incidence of viruses. Among 34 cultivated black raspberry samples, 21 tested positive for having at least one virus (62%), with 5 of these having one additional virus, and 1 having 3 viruses. Twenty of the 21 had blackberry chlorotic ringspot virus. This virus is a major issue in the Pacific Northwest where black raspberry planting life has been greatly reduced due to its presence. Of the 20 samples with this virus, two also had black raspberry necrosis virus, one had tomato ringspot virus, and two also had one of the two unnamed viruses. The sample with three viruses contained blackberry chlorotic ringspot virus plus black raspberry necrosis virus plus an unnamed virus. One sample had both blackberry raspberry necrosis virus plus an unnamed one. One sample had tomato black ring virus alone.

Among 44 cultivated red raspberry samples, 17 tested positive for at least one virus (or 39%). 13 were positive for blackberry chlorotic ringspot virus with only 1 of these having a second virus (an unnamed one). Four were positive for black raspberry necrosis virus, and only 1 of these had a second virus (an unnamed one). No viruses were found in the yellow raspberry samples, but there were only 3 samples of this bramble type.

Among 33 cultivated blackberry samples, 9 tested positive for having at least one virus (27%). Seven samples tested positive for blackberry chlorotic ringspot virus, with 2 of these also testing positive for black raspberry necrosis virus, and one testing positive for raspberry bushy dwarf virus. Two samples tested positive for black raspberry necrosis virus alone.

Interestingly, incidence in wild plants was lower than in cultivated plants and again, black raspberries were the type most frequently infected. Among 21 wild black raspberry samples, 5 tested positive for a single virus; one of these had apple mosaic virus, two had an unnamed virus, one had blackberry chlorotic ringspot virus, and one had raspberry bushy dwarf virus. Among 11 wild blackberry samples, only 1 tested positive for one virus. Among 4 wild red raspberry samples (Rubus ideaus var. strigosus) no viruses were detected, nor were any found in three samples of wineberries or a dewberry sample.

Management

Buying plants from sources that conduct virus testing and virus indexing is highly recommended, as always. It is also important to control vectors where they can be controlled such as aphids, thrips, and leafhoppers (and whiteflies where they may be present such as in high tunnels). Unfortunately though, because the most common virus found, blackberry chlorotic ringspot virus (and also raspberry bushy dwarf) are pollen-borne, that means that the vectors – pollinators and wind – cannot be controlled. It does mean, however, that it is especially important to isolate new plantings from older plantings and also from wild plants or other plantings of the same type. Testing for nematodes prior to establishing a new planting is always a good idea, as the nematode-transmitted viruses have wide host ranges including some common weeds - fumigation can help temporarily, but in bramble plantings which are fairly long-lived, nematodes will move upwards from depths below the fumigated layer. Plantings that are no longer productive should be removed sooner rather than later, but if they are being removed when leaves are present, spray them with an effective insecticide to minimize movement of vectors into healthier plantings, or remove them during the dormant season.

BLUEBERRIES: MARCHING TO THE BEAT OF A DIFFERENT DRUMMER

Bob Pollock
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Blueberries fall into an entirely different plant family from most other food crops. This plant family, the Ericaceae, includes azaleas, rhododendrons, mountain laurel, and teaberries (wintergreen). These species are often found growing together in nature, as their needs are similar. The native soils in which they thrive are typically low in pH (i.e., acidic), high in organic matter, low in phosphorus and calcium, and porous. Forest understories, bog areas, and pine barrens are all common locations where wild blueberries grow, though the species vary depending on location and conditions.

Most of the roots on a blueberry plant are extremely fine (only about the width of a human hair), so they are fragile, and are usually shallow. These roots can easily find their way through porous and high organic matter soils such as the ones in their native ecosystems, but they don't make their way into heavy soils that are low in organic matter. They also form associations with specific types of mycorrhizal fungi that act as an extension of their root systems, and that help them take up nitrogen from organic sources like decomposed organic matter. These species of fungi are not the same types that are frequently commercially sold.

Blueberry plants are native to North America and are ancient plants, but they have been commercially cultivated for only a little over 100 years. That is only a moment in agricultural history compared to most other crop plants. Thus, they still have essentially the same needs as wild plants. However, observing where they grow in nature can result in misunderstandings of what they need. The fact that blueberries are found in boggy areas makes it seem like they should grow well in wet spots in the field, but that's not the case. When blueberries are growing in bogs, they are often on small hills made up mainly of sphagnum moss or other organic matter, there is an entire ecosystem of aquatic plants and wetland creatures, and they are still getting plenty of oxygen to their roots. I equate these natural systems with being nature's hydroponics setup. This is unlike a poorly aerated, waterlogged part of the field where water molds like Pythium and Phytophthora grow best.

Blueberry Nutrition Basics

Native blueberries grow in soils that are low in certain nutrients. However, the most common problems we see with blueberries are nutrient deficiencies. Why? The answer lies in the conditions we try to grow them in, and in differences in nutrient availability and uptake.

The optimum pH for blueberry growth is 4.5 to 5.0, or up to 5.2 if in a clay soil. Blueberries need the complement of nutrients and nutrient forms that are available from low pH soils.

One nutrient deficiency we commonly see in the plants is low nitrogen. Blueberries use the ammonium form of nitrogen, while other crop plants use the nitrate form. Under low pH conditions, more of the nitrogen is in the ammonium form, whereas when the soil pH is higher, more of the nitrogen is in the nitrate form, which blueberries have trouble taking up and transporting within the plant. It is important to keep the soil pH low and therefore we recommend only nitrogen fertilizers for blueberries that supply nitrogen in the ammonium form. These would be ammonium sulfate (21-0-0) or urea (46-0-0), or other fertilizers with the word "ammonium" in their name - when other nutrients are also needed. Nitrogen tie-up when too much undecomposed organic matter is applied to the soil is another reason we sometimes see nitrogen deficiencies.

We also see low magnesium and occasionally low potassium. Soil magnesium, potassium, and calcium compete for exchange sites on the soil and the roots, so too much of one negatively affects availability of the others. Thus, when

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our soils are high in calcium, as many of our best agricultural soils are, we tend to see deficiencies of mainly magnesium. Foliar sprays of magnesium, usually in the form of Epsom salts (magnesium sulfate) are helpful, and soil applications of Epsom salts are as well, but much more needs to be applied. Eventually, if the soil pH is acidic, some of the calcium will be 'bumped off' of the soil exchange sites by hydrogen, but this will take several years. If potassium is low, potassium sulfate, or sul-po-mag (if magnesium is also low) can be used.

We see low iron and zinc mainly when the soil pH is too high (i.e., close to neutral or basic), as these micronutrients are less available from the soil at higher pH levels. However, we also see these deficiencies when the soil pH is in the correct range, but soil phosphorus levels are excessive. At low soil pH levels, phosphorus can form complexes with iron and zinc, so if an excessive amount of phosphorus is available and the soil pH is low (as we want it to be with blueberries), iron and zinc can be tied up. To correct these issues, the first step is to get the soil pH into the correct range before the plants are planted. If soil phosphorus levels are high, foliar sprays or regular soil applications of micronutrients may be needed.

Keys to Successful Establishment

First, get the soil pH into the correct range. Soil test at least a year before planting. The results will provide a recommendation for adding sulfur to lower the soil pH and elemental sulfur is the least expensive form. Soil microbe activity is needed to start the process, so you won't see much pH change unless the soils are warm enough for the microbes to be active. Pelleted sulfur is easy to work with, but we've found that the pellets sometimes don't degrade, slowing the entire process. Checking the soil pH again before planting will show if additional sulfur is needed.

Second, incorporate peat moss, enough to replace about half the volume of the soil when you fill in the planting hole. A cubic foot-sized planting hole works well, though some growers work the peat into the entire row length. The pH of peat moss ranges from 4.3 to 4.8, and by mixing the peat in, you are immediately making an environment in which the soil pH is close to the correct range, and the soil in the shallow root zone is more like a native "blueberry soil". Further, the peat makes it easier for the blueberry roots to grow into the surrounding environment, and it helps hold water and nutrients that the plants can more easily access. Decomposed softwood sawdust (preferably) and decomposed hardwood sawdust are much better than no organic matter, and they help with soil structure, and water and nutrient-holding capacity, but both have a higher pH. An ongoing study at the Penn State Horticulture Research farm is showing the best results with using peat moss for providing organic matter in the planting hole.

Third, mulch with organic matter about four inches deep, and keep the depth maintained over time. For this purpose, peat won't work very well, so you will need to use another material. Pine straw is great, but availability is an issue. Aged sawdust, bark mulch, a mixture of the two, or chipped materials from line-clearing work are much better than nothing, but we are finding that the pH of these materials can be very high. The pH of the soil creeps back up over time also, so you will need to check the pH in your planting, and probably need to make future sulfur applications.

Fourth, make sure you have trickle irrigation available for dry spells. The fine blueberry roots can dry up and die quickly.

Fifth, incorporate fertilizer as recommended by soil test results before planting. Only apply light doses of nitrogen in the year of planting, about 10 pounds per acre of actual nitrogen when the plants put on their second flush of growth, which should happen about two weeks after they first leaf out, and another 5 to 10 pounds of actual nitrogen per acre about 6 weeks later. This is only about a half-tablespoon of ammonium sulfate per plant at a time, applied in a circle about 6 inches from the stem. Do not over-apply; you do not want to burn the roots. You will make similar applications in year two – 10 pounds of actual N per acre at bud break and then 6 weeks later. Gradually increase the nitrogen rate by about 10 pounds of actual nitrogen per acre per year until you reach a maximum of 60 to 65 pounds per acre, split into two applications – the first at budbreak and the second six weeks later.

Finally, be sure to remove flower buds in at least the first two years, and possibly some of them in the third year. Based on our experiences, you only delay reaching full harvests if you do not. Leaving them on is tempting, but as in so many aspects of life, patience will pay off down the road.

CARING OF FIG TREES

Bill's Fig Trees, William Muzychko
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Mr. Muzychko is the founder and owner of Bill's Figs located in Hunterdon County, New Jersey. At Bill's Figs he manages every stage in the life of a fig tree including the planting, growing, picking, pruning and winterization of every tree he grows. He now has over 130 varieties of fig trees.

Fig trees are warm weather plants that need special care in cooler climates such as New Jersey. Fig trees cannot survive outdoors in the northeast without being sheltered or covered. Remember helping your grandfather use tarp, burlap, insulation and whatever else was available to wrap his fig tree like a mummy for the winter? Or did your father dig a trench and try to get all the branches of the tree bent over and covered in the trench for the winter?

This explains the cumbersome and unsightly contraptions that folks have developed to protect their fig trees from killer frosts that are so common in our area during the winter.

Mr. Muzychko has developed a system that not only eliminates the need to "bury" fig trees during the winter months but also dramatically increases crop output. Each of his trees comes with a unique, built-in irrigation system that will allow you to bring your tree into your garage or barn for the winter, if purchased. His system guarantees that your fig tree will be given the correct amount of water and fertilizer that it will need at any given time during the year.

Come springtime, instead of being faced with the unpleasant task of having to remove all of the tar-paper, old carpets and cardboard boxes that you used to swaddle your fig tree during the winter, all you have to do is bring the fig tree that you purchased from Bill's Figs outdoors for the growing season.

Bill's watering and potting system eliminates all worries with over wintering your tree. Just move your tree into an unheated garage or shed and let it rest, dormant for the winter. Then remove it in the spring. No winter care at all! Below are your simple to follow care instructions.

1. **Placement of your tree.** Place your tree in a sunny outdoor place, once all chance of frost is over or cover the tree when frost is predicted. Bring it out in mid-April. It can remain outdoors until the end of November. If the weather remains warm a few of the fruit currently on your tree may ripen yet this year.

2. **Watering.** Water your tree using the patented watering system. There is a watering spout at top of the pot, near the base of the tree. In the cooler weather of the fall your tree can probably be watered every 3 or 4 days. In the summer your tree will need to be watered every day. With the EZ-Care watering system there is no worry or guesswork. You cannot over water your tree. On the side of the pot there is an overflow weep hole. When your tree has enough water it will overflow out of the hole. If you wonder whether your tree needs water, try watering it and your question will be answered virtually immediately. Do not permanently remove the black plastic on the top of the pot. It insures that water is not lost to the air (and also helps keep the roots warm in early spring and prevents weeds from growing).

3. **Over-wintering.** Your tree will survive the first frost – so do not worry. It will not survive a heavy period of freezing. Given normal weather conditions, your tree can stay out doors until Thanksgiving, by which time it should drop its leaves and go dormant for the winter. Bring your tree into an unheated garage or shed and place it in a darker area for the winter and forget it until spring. The shed or storage place should not freeze and the temperature should be kept just above freezing. It should be watered periodically, ie. once a month, no other care is needed for the winter. Bring your tree out doors when all danger of frost has passed. Place it in sunny area and water! You are set.

4. **Trimming.** You should trim the tallest branches of your tree back by up to one third of their length before you bring it indoors. Do not worry. You can not make a mistake. Fig trees love being cut back and 3 or 4 new

branches will appear the next year where you cut the branch back. And figs develop on the near year's growth so your trimming will bring you a larger crop. If you want to keep the tree its present size for over wintering storage or to make it easy to move, trim it to your needs in the fall. Your tree can be moved with a standard hand truck initially and then with a fig mover (see Bill).

5. **Fertilizing.** Your tree is already potted with fertilizer. However you should reinvigorate the fertilizer once a year in the spring. "This takes around 5 minutes". Remove the black plastic cover. Take about (7 oz) of Osmocote fertilizer for the garden (14 – 14 – 14) and work it into the top of the soil. **FOLLOW THE LABEL DIRECTIONS ON THE FERTILIZER.** Do not over fertilize. Your tree will be unhappy. Once in the spring is enough. When first potting the tree, stir in 10 cups of granular limestone to adjust the soil PH. Figs thrive at a soil PH of 7.75 – 8.00.

6. **Picking the fruit**. Fig trees do not flower. You will see the small figs develop late in the spring. Your crop will begin to come in, in late summer (late August or September). The fruit are ready when they start to feel soft. Some year's particular varieties may develop ripe fruit in the early spring and then again in the late summer.

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EFFORTS TO ESTABLISH A NATURAL ENEMY OF SPOTTED-WING DROSOPHILA IN THE MID-ATLANTIC AND BEYOND

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Spotted-wing drosophila (SWD), an invasive fruit fly from eastern Asia, has been a major problem for berry crop producers since it first arrived in the continental U.S. in 2008 and the northeastern U.S. in 2011. Females lay their eggs in ripening fruit, so berries are often infested with tiny white larvae anytime from mid-summer on, requiring producers to spray insecticides on a weekly schedule to keep SWD numbers low enough to prevent losing the crop. To date, these insecticide sprays have been the only sufficient means of control, though exclusion netting and other cultural control practices have also been used successfully in small plantings.

Within its native range, differences in cropping systems and several species of natural enemies help make SWD more manageable. Although a number of generalist natural enemies that feed on other fruit flies will attack SWD in the U.S., its populations build too fast to be effectively controlled by predators. Parasitoids lay their eggs inside pests and develop within them, emerging instead of the pest adult, and are typically better able to keep up with pest populations. However, SWD has a particularly strong immune system that can kill native parasitoids that attack it in U.S. cropping systems.

Efforts had been undertaken by personnel at the USDA's Beneficial Insects Introduction Research Unit (USDA-BIIRU) in Newark, DE to identify more effective parasitoids that could be safely introduced to the U.S. One in particular, *Ganaspis brasiliensis*, was found to be a particularly good candidate. This tiny wasp, the size of a lower case "i" in this text (minus the dot), is native to Asia. It had been found in British Columbia in 2019, and in 2021, it was found in Washington State. Females lay their eggs in SWD larvae, and wasp adults emerge from the SWD pupae instead of an adult fly.

Because the native environment of *G. brasiliensis* is very similar to that in the Mid-Atlantic region (and other areas of the U.S.), it is expected to be able to establish and survive here on its own. Thus, the goal is to release the wasps in wooded areas on farms with wild host plants which provide overwintering habitat for SWD and from which it disperses in the spring. Natural enemies tend to be sensitive to insecticides, so there was concern that releases of *G. brasiliensis* in cultivated crops alone might not result in successful establishment and SWD control. If *G. brasiliensis* establishes and multiplies on SWD in wooded areas, SWD numbers dispersing to cultivated crops should be reduced, thus resulting in a delay until the first sprays are needed, perhaps eventually reducing the need for them altogether.

What Efforts are Underway, and What Are We Finding Out?

<u>New Jersey</u>. In a coordinated effort between Rutgers University and NJ Department of Agriculture Phillip Alampi Beneficial Insect Rearing Laboratory, a total of 1000 *Ganaspis brasiliensis* adults were released per farm on five commercial

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Kelly Hamby is an Associate Professor and Extension Specialist in the Department of Entomology at the University of Maryland, and she works with insect pests of small fruit and grain. She received her B.S. in Environmental Toxicology, M.S. in Entomology, and Ph.D. in Entomology at the University of California Davis. Originally from California's Central Valley, she and her husband Scott now live in central Maryland where they enjoy bird and insect watching.

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.

blueberry farms in Atlantic and Burlington Counties. Releases took place in July and August 2022. Parasitoid surveys were conducted prior to the release of *Ganaspis brasiliensis* in June and July, and after releases in August and September. At each farm, sentinel traps baited with SWD-infested fruit were deployed together with direct collections of wild fruits in non-crop areas surrounding the farms. Parasitoids of drosophilids, such as those in the families Ichneumoinidae, Figitidae, and Diapriidae, were identified from these traps and fruit collections both prior to and after the releases of *G. brasiliensis*. During the post-release surveys, *G. brasiliensis* was recaptured on both baited traps and wild berries; these results show that *G. brasiliensis* was successful at surviving during the first months after release. Samplings during the Spring of 2023 are needed to show the winter survival.

<u>Maryland.</u> In 2022, we released wasps in non-crop habitat at two central Maryland commercial diversified farms and near unsprayed berries at the Western Maryland Research and Education Center. 250-500 wasps were released per site and release date, with one release per month from August to October. Non-crop and crop fruit were collected during and after the releases to determine whether SWD was being parasitized by the wasps. Most of the wasps were found where and when heavier SWD pressure was occurring and were recovered from cultivated blackberries and red raspberries. A few wasps were also recovered from honeysuckle, pokeberry, and wild blackberries. In total, we recovered over a thousand wasps from about 8 pounds of fruit. During our sampling, we observed wasps searching cultivated fruit for SWD and our efforts went better than expected. We are cautiously optimistic that the wasps will survive the winter, and we will sample next year to see if they are becoming self-sustaining.

<u>Pennsylvania.</u> Efforts were coordinated with Univ. of Maryland and USDA-BIIRU personnel in Delaware where similar releases were taking place. In PA, three releases of wasps were conducted on a commercial farm in Centre County in August, September, and October and two were conducted on a commercial farm in Adams County in August and September, with 750 to 1500 wasps being released each time depending on date and location. Monitoring was then conducted to determine how far the wasps dispersed, how quickly, which berries new wasps emerged from in the highest numbers, and what the parasitism rate was. In Centre County wasps dispersed, found SWD, and multiplied more quickly than we expected, being recovered from SWD larvae from wild blackberries over 350' from the closest release point one week after the first release (though the wasp species has yet to be confirmed), and over 600' away from the closest release point by the end of the season - the farthest distance from release points to be checked. Wasps were also recovered from cultivated blackberries, red currants, Amur honeysuckle (an invasive species that fruits in Fall), pokeberry, and autumn olive, though Amur honeysuckle appeared to be a preferred host. No SWD or wasps were recovered from wild black cherries or a native wild grape species. Wasp numbers were moderate, with over 200 being recovered from less than 2 pounds of fruit.

In the course of this work, another SWD parasitoid that is native to southeastern Asia was found to be present in Adams County in pre-release samples. How long it has been here and how quickly it is multiplying is not known, but this finding is a positive one, as research conducted elsewhere has shown higher SWD parasitism rates when both species are present.

Future Plans

Monitoring and future releases are planned. Starting in December of 2022 until May of 2023, an overwintering experiment will be performed to study the survival of G. brasiliensis during natural field conditions. Next spring, data will be collected to find out the extent to which the wasps overwintered, when (hopefully) they emerge, and what plant species may be most important for their early season multiplication.

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HOW AUGMENTED REALITY AND BLOCKCHAIN MIGHT HELP BUSINESSES ACROSS NATURAL RESOURCE AND FOOD SYSTEMS.

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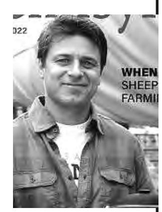
Agriculture has been at the forefront of business and societal technology innovation for centuries—everything from the steel bottom plow to modern plant breeding practices. As farms become more connected in terms of on-farm information and customer connection, the technology options available to potentially help build greater efficiency, sustainability, growth, competitiveness, and profitability are also growing. The goal of the How Augmented Reality and Blockchain might help Businesses across Natural Resource and Food Systems program is to introduce two of those technologies currently coming online that may have meaningful benefits for farmers.

What is Augmented Reality? Augmented Reality (AR), not to be confused with virtual reality, is an immersive experience that overlays holographic visuals over the user's physical world. Unlike virtual reality that (virtually) transports one into a pre-programmed setting (for example, to a tropical island), augmented reality is rooted in the real-world and real-time experience of the user. AR provides feedback in response to the visual inputs to help the

Terry P. Harrison serves as Professor, and Earl P. Strong Executive Education Professor in Business for the Penn State Smeal College of Business. Professor Harrison has teaching and research interests in the areas of supply chain management and modeling, large-scale production and distribution systems, decision support systems, applied optimization, and the management of renewable natural resources.



Daniel Dotterer's family has been farming in Pennsylvania since 1722. The family beef farm he grew up on in Clinton County has been in the family since 1819. After graduating from Penn State University with a degree in pre-med, he moved to Los Angeles, California. There he spent over a decade working in the Entertainment Industry and worked his way up to Producing on TV Shows, Movies, and Game Shows. One of the most well-known projects he worked on was the animated movie Despicable Me. With the freelance nature of his work, he always spent at least a couple of months each year back home on the farm. Five years ago, he was introduced to Augmented Reality by an Executive at Microsoft, and he was hooked. He has been working on developing AR's uses in Agriculture ever since. When Daniel moved back home several years ago to take over the family farm, he switched to Katahdin hair sheep and grew his herd to over 350 animals.

Cristy Schmidt serves as an applied research educator for Penn State Extension. Cristy is directly affiliated with the Penn State Center for Economic and Community Development within the College of Agricultural Sciences, and serves as the County Commissioners Association of Pennsylvania (CCAP) Extension Fellow. Through her work, she collaborates with faculty, staff, and undergraduate research assistants to conduct applied research that addresses emerging social and economic issues in communities and regions across the state. She specializes in community and neighborhood development, economic development, secondary data analysis, data visualization and communication, public administration, and public policy.

Jim currently serves as the Penn State Extension as State Program Leader and Solutions Architect for Emerging and Advanced Technology and Co-Director of the Penn State Marcellus/Energy Center for Outreach and Research. Through his State Program Leader responsibilities, he supports the exploration of innovative technology and connected digital infrastructure, with the ability to enhance data-driven decisions for efficiency, sustainability, growth, competitiveness, and profitability of food, farm, agriculture, environment, and natural resource businesses.

Projects already underway include serving as the official broadband mapping entity for the Commonwealth of Pennsylvania, on-farm producer-led blockchain deployment, augmented reality systems development, and connected farm information and device infrastructure. Recent successes include a partnership with the PA-PUC, which helped bring $368 million in new investment to Pennsylvania broadband infrastructure, and working with the Smeal College of Business to deploy a Blockchain producer survey targeting the opportunities and challenges of blockchain for small and mid-sized producers.

users experience something new, make decisions, or perform tasks.

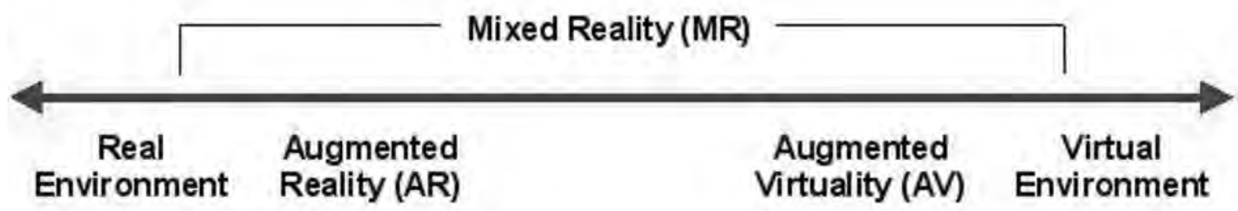


Figure 1. Milgram & Kishino's Virtuality Continuum

AR may be a powerful tool in data-driven agriculture, giving farmers access to information to make good decisions when and where they need it, saving time and money. Imagine a farmer walking through their field, viewing production history, production inputs, disease and insect pressure, and more, without opening a computer. That farmer may also be able to use AR to utilize remote services, replacing routine technical visits (equipment, sales, and service, etc.), thereby extending the capacity of technicians for speedier service and reducing farmer costs.

A field crop farmer might use AR to identify rock outcroppings or other hazards in their field to guide themselves or their crew around those areas during planting. The operator could see the no-plant zones through their headset display and perhaps even follow holographic tire tracks around the area. Similarly, AR may assist growers in precision agricultural practices such as soil monitoring and input applications by identifying and giving visual cues for the site needing attention.

The applications for agricultural workforce development could be endless. AR puts expert knowledge and guidance at the user's fingertips, from new-hire orientation to advanced skill training. Wearing AR-enabled glasses, a new employee could learn the uses and storage locations of common tools, take an AR-guided tour of the facility, and work through a checklist of end-of-shift protocols without papers or handheld devices.

The potential applications for AR in agriculture are vast and varied and just beginning to be explored to help build greater efficiency, sustainability, and profitability. Integrating farm-specific data, expert wisdom, and real-time observation could give farmers greater access to decision-making tools than has ever been possible. In the future, AR, as part of a data-driven farming strategy, may be a vital tool for enhancing efficiency and competitive advantage among farms.

What is Business Blockchain? Blockchain is a virtual record-keeping system that maintains a log (a "chain") of transactions or activities (via "blocks"). Blocks contain data, which vary by the type of information the specific blockchain tracks, and a unique digital fingerprint known as a "hash." Each block also contains the previous block's hash, which allows blocks to be strung together in a chain.

Blockchain is a distributed ledger, meaning it exists not in a centralized location but as decentralized identical digital copies across many devices and participants. Ledgers have been used for centuries to record sales, transactions, and the movement of property. Originally, ledgers were written by hand, typically by a bookkeeper or someone responsible for logging transactions. Today, ledgers can be electronic and automated without needing a person to manage the process. Traditional (centralized) ledgers managed by a few parties can be vulnerable to forgery and manipulation.

In contrast, distributed ledgers and their transactions are viewed and verified by many parties (primarily by their computers) across the globe, making forgery and manipulation of the ledger extremely difficult and unlikely. Once the blockchain user network verifies a transaction by reaching a consensus that it is valid, it becomes an official part of the blockchain. This means that all members possess a record of the transaction, becoming nearly impossible to change later because the person or computer attempting to alter the record would have to manipulate each copy separately.

Applications for blockchain technology are almost limitless. Blockchain can also log, verify, and reduce paperwork for sales and ownership history of property like land, vehicles, and commodities. Contract and payment automation using blockchains can save staff time in an era when many companies face staffing shortages. Essentially anything where data or transactions need to be accurate and verifiable, can be built into a blockchain, preferably controlled by the farmer.

Blockchain's potential in the food supply chain is equally vast. Now more than ever, shoppers express a desire to know where their food comes from and how it is produced. They want to see the farm, meet the farmer, and feel connected to the system that delivers the food to their plate. Food and other consumer-good supply chains can use the technology to share information with the public that might not otherwise be feasible. For instance, companies can verify the product's point of origin (specific farm, harvester, or maker) and date of harvest or creation. A unique identifier such as a QR code can allow customers to access these select data points within the blockchain by simply scanning or entering the unique product code. With over 100 million people within 400 miles of Hershey, this level of transparency may boost consumer connection, ag literacy, and trust.

Blockchain is also a powerful tool for food safety. Food can be accompanied by valuable food safety information like handler names, timestamps, and storage temperatures from the farm to checkout at the store. In the event of a food safety event (illness, contamination, or other problem), a recall can be isolated to specific batches of problematic products rather than entire geographic areas or product types, thereby helping keep farms in production and reducing the cost, risk, and impact on farmers. Large food retailers like Walmart are already utilizing blockchain to trace products to suppliers, and it seems likely that blockchain adoption will eventually expand to smaller-scale retailers as well.

The countless opportunities for using blockchain in agriculture and other sectors are still coming to light. What does seem clear is that it wields immense potential for increasing efficiency, reducing human error, mitigating risk, and growing trust—these qualities position blockchain as a powerful emerging tool in a competitive marketplace.

**Augmented Reality and Blockchain overview adapted from work by Becky Clawson, Food Systems and Local Foods Extension Educator based in Lancaster County

Penn State Extension Emerging and Advanced Technology Initiative Overview

Purpose: To explore innovative technology and connected digital infrastructure relevant to stakeholder needs, with the ability to support data-driven decisions for efficiency, sustainability, growth, competitiveness, and profitability of food, farm, agriculture, environment, and natural resource businesses.

Intention: To empower individuals, businesses, and communities across the food system with advanced technology and connected digital infrastructure options that enhance their capacity to manage resources more effectively and efficiently.

Focus: In keeping with the unique land-grant mission, value of engaged knowledge work, and desire to foster positive innovation, the emerging and advanced technology initiative will be built on:

- Connection to stakeholders and positive stakeholder impact
- Relevancy & usefulness
- Empowering individuals and businesses through data-supported decisions
- Technology integration cost-benefit
- Scalability across the food system
- Potential to enhance sustainability, efficiency, growth, competitiveness, and profitability
- Enhancing accessibility, equity, adoption, utilization, security, & policy

Current Integrated Technologies of High Interest

- Augmented/Mixed Reality
- Business Blockchain
- Connected Farm Information and Device Infrastructure
- High/Low-Frequency RFID
- Artificial Intelligence
- Machine Learning
- Equipment & Digital Infrastructure Integration

GROWING AND MARKETING GINGER IN HIGH TUNNELS

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Ginger (Zingiber officinale) is a perennial plant that is native to tropical regions of Asia. The continental United States imports most of its ginger from other countries, or from Hawaii, but baby ginger can also be grown locally in temperate regions. Recently, farmers throughout the Northeast have been having success growing baby ginger in high tunnels. Fresh baby ginger is a unique product that is different than the mature ginger that is sold in grocery stores and has potential as an excellent niche crop for farmers markets, restaurants, CSAs, and other direct marketing customers.

Growing Methods

Pre-sprouting the Seed Pieces

Ginger requires a long growing season to produce a harvestable crop. In the Mid-Atlantic region, this involves pre-sprouting the ginger seed pieces in late February or early March in a heated greenhouse before they can be transplanted into the field. The seed pieces are sections of the rhizome, generally weighing 1 to 2 ounces each. Seed should only be obtained from a reputable supplier to minimize the potential for any disease issues on contaminated seed.

To pre-sprout the ginger, spread seed pieces out in a single layer in flats and cover with 1-2" of soilless potting mix. Pre-sprout in a greenhouse maintained at 70-75oF. Heat mats set to 72oF can help to maintain an even and consistent temperature in the root zone. A germination chamber or heated room can serve as an alternative to greenhouse pre-sprouting. Once shoots begin to emerge, the flats should be moved into a space with adequate light. The medium in the sprouting trays should be supplied with adequate moisture but not over-watered. Shoots will emerge out of the medium and roots develop over a 6-8 week period.

Planting the Seed Pieces in the High Tunnel

When soil temperatures in the high tunnel are consistently 55oF or higher, the sprouted seed pieces can be planted into the soil. This is likely to be in late April or early May, depending on the season. Ginger is a heavy feeder and grows best with compost additions and supplemental nitrogen (100 lbs. N/acre before planting plus two additional applications of 25 lbs. N/acre during the growing season). A neutral to slightly acidic pH (approximately 6.5) is recommended, and adequate calcium is important for the crop. Drip irrigation is also recommended to conserve water and reduce the leaf wetness period.

Sprouted ginger seed pieces can be planted 2-3 inches deep, 4-8 inches apart, and with 2-3 feet between rows. Approximately 25 lbs. of seed will plant 150 row feet. However, the initial size of the seed pieces will also influence how

Alex Sawatzky studied history in college but found his passion for growing food while participating in a nine-month internship at a sustainable education center in Costa Rica. Upon returning to the States, he began his farming career as an intern at a diversified vegetable farm in Pennsylvania in 2010. He then went on to start Sandbrook Meadow Farm in Stockton, NJ—a certified organic farm where he managed a 300+ member CSA and sales through farmers markets, restaurants, and grocery stores. With an aspiration to teach sustainable agriculture, Alex went back to school to secure a master's degree in sustainable food systems while continuing to farm. He joined Rutgers University in April 2019 as the Rutgers Gardens Student Farm Manager. He is also a part-time instructor in the Agriculture and Food Systems Program, teaching "Principles and Practices of Small-Scale Organic Farming" and "Applied Practical Applications in Agriculture and Food Systems".

many row feet can be planted per pound of seed. Plants should be hilled 1-2 times throughout the growing season as the shoots grow taller and the rhizomes emerge above the soil line.

Disease Management

Ginger is susceptible to bacterial wilt, bacterial soft rot, Pythium, and fusarium. Purchasing disease-free seed stock is the first line of defense against these problems. Soil-borne nematodes can also be a potential pest of ginger. It is important to avoid planting in areas where other crops that are susceptible to these pathogens have been recently grown to further minimize disease pressure. Growing the crop in a high tunnel not only provides necessary temperature modification, but also protects the crop from excessive rainfall events, which can lead to overly saturated soils and the development of disease problems.

Harvesting Ginger

Ginger is generally harvested from late September through the beginning of November. The plants are pulled from the ground using a digging fork and care should be taken not to damage the delicate skin of the rhizome. Stems and roots are removed with a sharp knife or shears prior to washing. Baby ginger is perishable and will store for about two weeks in cold storage.

Results

In our trials, harvested ginger yields by weight ranged from 2.1 to 2.7 lbs. per foot (non-organic) and 1.1 to 1.9 lbs. per foot (organic). This is not direct side-by-side comparison, as the trials were conducted at different locations using slightly different production methods across two years. Baby ginger retails for approximately $16 per pound at farmers markets and can wholesale for $10 per pound. At retail prices, baby ginger can gross between $25-$38 per linear foot of bed space planted, making it a potentially very valuable crop for Mid-Atlantic growers who are involved in direct market sales.

The baby ginger from these trials was sold at a farmers market and samples were donated to local restaurants and other businesses with a survey to complete. The high level of satisfaction from local restaurants and breweries, combined with their willingness to purchase baby ginger from growers further indicate the potential for growing and marketing baby ginger as a niche crop in the Mid-Atlantic region.

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