Proceedings

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RUTGERS New Jersey Agricultural Experiment Station

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Session 1

Organic Production

Session Chairs:
Megan Muehlbauer
and
Meredith Melendez

NON-HERBICIDE WEED MANAGEMENT RESOURCES

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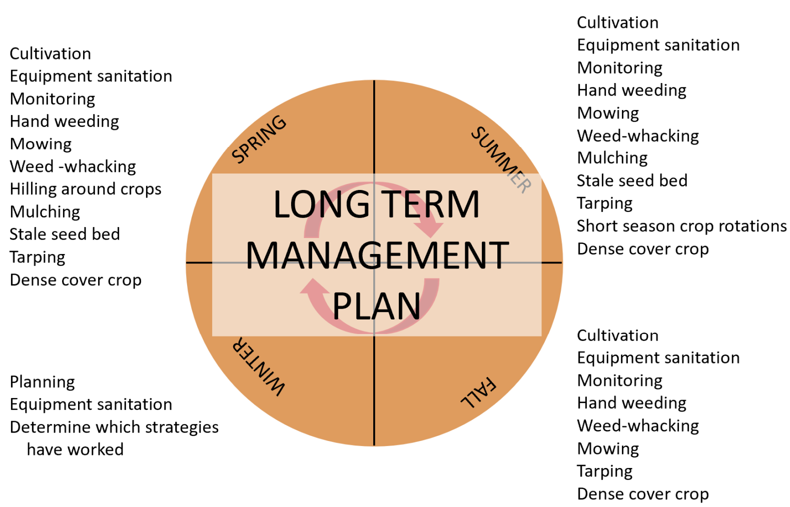
Fruit and vegetable farmers in New Jersey have expressed their need for science-based information to assist them in weed management decision making. Specialty Crop Block Grant funding was obtained to develop educational resources and to conduct a comparison trial of herbicides listed as Organic Materials Review Institute approved. This organic herbicide trial is part of a NJ Department of Agriculture funded Ecological Weed Management project.

Five weeds were focused on for this project, Canada thistle, large crabgrass, hairy galinsoga, pigweed, and yellow nutsedge. Fact sheet decision tools were developed for each of these species along with a companion recording. These resources consider the life cycle and growth preferences of each of these species and provide information to assist the grower in the development of a multi-year plan of action. All of the species focused on in this project reproduce prolifically through seed formation and dispersal, except for yellow nutsedge. Yellow nutsedge spreads through root fragment dispersal and tends to not produce viable seeds. Canada thistle has an advantage by being a perennial weed that produces viable seed and spreads through root fragments. Resources included seasonal based activities to manage specific weed species, an overview of these activities is seen below. Access to the resources described here can be accessed through the QR codes included at the end of this abstract.



This project also sought to evaluate herbicides that are labeled for use on organic farms. The following Organic Materials Research Institute (OMRI) herbicides were used for this trial, with AIM as our conventional check herbicide:

Supress – Caprylic acid and capric acid (fatty acid)
Axxe – Ammonium nonanoate (soap of fatty acid/soap salts)
Green Gobbler – 20% vinegar
Avenger – d-Limonene (citrus oil)
Burnout II – Clove oil, vinegar, lemon juices

Our observations from this trial showed that the 20% vinegar and the ammonium nonanoate were more effective compared to the other OMRI approved products, particularly in the earliest sprayed plots when the plants were just emerged from the soil and most susceptible to the herbicide. None of the products were effective against the thistle or nutsedge.

The resources developed for this project can be found online using the QR codes below.

Rutgers NJAES YouTube Weed Management Playlist, video recording access

Non-Herbicide Yellow Nutsedge Management

Non-Herbicide Canada Thistle Management

Non-herbicide Redroot and Smooth Pigweed Management

Non-Herbicide Hairy Galinsoga Management

Project funded by USDA SCBG AM190100

ROAD TO CERTIFICATION

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What is Organic Production?

There is not a quick answer because it's one of the few, maybe the only production methods to be defined by a federal law. Since the passage of this law and the implementation of its accompanying regulation, the Federal Department of Agriculture has owned the rights to the word "Organic" and it applies to anyone selling over $5,000 of organic products per year. Most of the law is written in a positive manner – "You Must or May do or use…" However, there some basic prohibitions and this includes genetic engineering (including the seed), irradiation of the product and sewage sludge must not be used for fertility. Organic crops must also be harvested from fields free of prohibited materials for at least 3 years prior to harvest.

The Organic Certification process is undertaken by Certification Agencies. NOFA-NY https://nofany.org/, Pennsylvania Certified Organic https://paorganic.org/, and Bay State Organic Certifiers https://baystateorganic.org/, are three fairly local to our area. All certify to the same National Organic Programs standards and all undergo a continual accreditation process with the USDA. More can be found on the website of the National Organic program:
https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program

What are the Main Organic Crop Principles?

1. Must maintain or improve soil through:
   - Crop Rotations
   - Cover Crops
   - Application of plant and animal materials
2. May maintain or improve soil through:
   - Natural materials including mined minerals unless prohibited
   - Synthetic materials allowed by the regulation
3. Control pests with:
   - Cultural, mechanical and biological means
   - If not successful, with natural and allowed synthetic inputs
4. Must maintain or improve natural resources including soil & water quality

What are the benefits?

1. Improves soil health including increased organic matter with resultant moisture penetration and holding capacities.

What's the Market Outlook?

- Highest organic sales are in fruits and veggies

- Second highest is dairy
- As of 2019, price premium was 7.5% - 9%
- Growth of about 10% per year
- There are motivating factors why people buy organic and why they don't

How can I prepare for certification?

There is a 3-year transition period for land. Ruminant meat livestock must be raised organically from the last third of gestation. Dairy animals have a one-year transition period and poultry must be raised organically from one day old. Records during a transition period will be needed for seed purchases and field and animal inputs. A certification Agency will need to be chosen.

What's the process?

Request an application, fill it out and return to your chosen Certification Agency. This will include back-up documents such as field maps, field histories, and seed purchase records. Its likely more information will be requested. Responding quickly can speed the process. Once a preliminary approval is granted, an inspector will contact you to arrange a farm visit. After the visit, the inspector will submit a report. After certifier review, one of four outcomes can be expected: 1. Approval; 2. Approval with conditions; 3. Request for more information or 4. Rejection. Plan ahead, the whole process can take 2 months. Some certification agencies will speed-up the process for an extra cost.

What are some typical sticking points?

- Proposed and past use of inputs for fertility and pest controls
- Buffers with neighbors and roads
- Segregation practices on farms with both organic and conventional production.
- Seeds – verifying none genetically modified or treated with a prohibited substance were used in the last 3 years.
- Past history including birth and health inputs on livestock.
- Insufficient records during the transition period.

Soil Nitrogen Fertility for Organic Vegetable Production

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Nitrogen is freely available to all farmers who are skilled at cultural practices for capturing this element from the atmosphere. With a concentration of 80% N, the supply from air is unlimited. Growing cover crops for biological N fixation or legumes as part of a crop rotation are reliable and cost-effective ways put that N into soil and build soil fertility.

Some examples of potential legume contributions of fixed N to soil fertility: Alfalfa 200 lb./acre, red clover 100 lb./acre, sunn hemp 140 lb./acre, hairy vetch 150 lb./acre.

A crop following alfalfa in a rotation will almost always ensure that a soil is well supplied with N and no supplemental N fertilizer will be needed. Sunn hemp is a tropical legume that is becoming popular as a summer cover crop. It can supply substantial amounts of N to vegetable crops that follow it, but the N release pattern may not match the needs of the crop. Hairy vetch is a winter cover crop that also can supply substantial N, but that amount varies depending on the growth stage when it is killed or if it was grown with winter rye as a cover crop mix.

Where legume cover cropping cannot ensure adequate N supply, soil organic matter may provide the necessary balance provided good ecological soil fertility practices are being followed as is a requirement for organic certification. Each 1% soil organic matter content may release on average about 40 lb./acre of available N. Thus, a soil with 3% organic matter content could potentially supply 120 lb./acre of N. But these are only rough estimates that can vary depending on weather condition, especially soil temperature, and presence of decomposing crop residues.

Recycling natural waste materials via composting, applications of manure, and livestock integration into the farming system are all good cultural practices for supplying N as well as building soil organic matter content and supplying other valuable nutrients. However, in the case of non-composted manure use, organic vegetable growers must maintain a window of at least 120 days between time of application and harvest of vegetable crops.

Compost is great for building soil fertility and organic matter content, but it should not be used as the primary N source. Heavy annual applications of compost for the purpose of providing N to crops, typically oversupplies other nutrients such as P.

Although there are some organic approved N sources for crop production, these materials are usually expensive and bulky. Also, the available N from these natural source products may not match the N uptake needs of the crop. Thus, these materials should not be relied upon as a major N source for organic vegetable crop production. It is best to think in terms of developing an organic farming systems plan where a combination ecological cultural practices build up and maintain a soils capacity to supply N at rates that closely match crop demand.

Both conventional and organic growers are faced with the challenge of getting the supply of N on target to match crop demand. The crop uptake cycle for N is a function plant growth pattern. When plants are small, N uptake rates are low, but as the growth rate increases, the N uptake demand also increases. Growers must carefully manage complex inputs to the N cycle and make timely adjustments for possible N deficits if necessary. Ideally organic growers should build some insurance N fertility into the system to avoid the need for sidedressing with expensive N fertilizers.

The presidedress soil nitrate test (PSNT) is a useful tool to gage plant-available N contributions from manures, legumes, and organic matter. The PSNT test method calls for taking soil samples from 0 to 12-inch depth, during the growing season, when the crop is at an early vegetative growth stage. This timing is still early enough to add supplemental N fertilizer if necessary. This soil test for N is useful for a wide range of vegetables that are grown as annuals. The PSNT is not suitable for perennials or tree crops.

The PSNT specifically measures nitrate-N concentrations. Testing for ammonium-N in the soil generally does not improve ability of the PSNT to make correct predictions. Besides nitrate and ammonium, there are other forms of N that may be taken up and utilized by plants. But just measuring nitrate provides an accurate index of N availability for predicting N sufficiency or the need for supplemental N fertilizer.

In most cases the soil test will hopefully find that the soil N supply is adequate, and sufficiency should be the soil fertility building goal of organic vegetable growers. But when the PSNT identifies N deficient soils, supplemental N may be applied along beside the row using an organic approved N source. Hopefully under good organic farming management this will not happen often.

In other instances, the PSNT may find that the soil nitrate level is much higher than the sufficiency level of 25 ppm. Growers can also use this information to learn from experience that they are apparently adding too much in the way of organic inputs to cause an excess N supply in soil.

In summary, the PSNT is a useful diagnostic tool for organic vegetable growers to manage and adjust the N cycle to the needs of sustainable crop production.

For further information visit Rutgers NJAES on the web for fact sheet on “Soil Nitrate Testing as a Guide to Nitrogen Management for Vegetable Crops”.

Session 2

Wine Grapes II

Session Chair:
Hemant Gohil

CONVENTIONAL MANAGEMENT OF POWDERY AND DOWNY MILDEW OF GRAPES IN THE EASTERN U.S.

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Powdery mildew of grapes

1. **Biology/epidemiology on grapes**

Powdery mildew is caused by the fungus *Erysiphe necator*, and is found wherever grapes are grown, requiring management in wet *and* dry climates. Symptoms consist of white/grey fungal colonies (sporulation) on the surface of infected tissues, including the tops and undersides of leaves. Fruit/cluster infections generally precede leaf infections. Each spring, powdery mildew disease begins when overwintering structures (chasmothecia) on the wood of the vine, release spores (ascospores) during wetting events of at least 0.1" rain and average of 50° F during wetting. These wetting events generate *primary* infections that lead to *REPEATING secondary cycles* of the disease. Secondary cycles of the disease are what lead to epidemics during summer. Under ideal summer conditions (cloudy, high humidity, mid 60s to mid 80s F), the powdery mildew fungus can go through an entire secondary life cycle in 5-7 days. Since secondary cycles of the disease do NOT require any rainfall, "ideal" conditions occur frequently during the summer months. Therefore, every day, from June through September, can be considered a powdery mildew infection period, enabling this disease to quickly spin out of control in your vineyard if not adequately controlled!! Leaves and cluster rachises are susceptible all season. Fruit are susceptible from capfall (beginning of bloom) through 2-4 weeks post bloom.

For fruit protection: immediate pre-bloom and first/second post bloom sprays are CRITICAL!: use best fungicides, short spray intervals (7-14 days), best coverage, SPARE NO EXPENSE AT THIS TIME! Powdery mildew fruit infections shortly after bloom (June/early July), create injuries in the berry skin that act as entry points for other fungi and bacteria to invade the fruit, and contribute to greater bunch rot problems months later, during ripening. Native grape varieties are least susceptible, *Vitis vinifera most susceptible*, and hybrids are of variable susceptibility.

2. **Control of powdery mildew**

Cultural control: There are a number of non-chemical methods that can be integrated into chemical control programs to boost the effectiveness of powdery mildew management efforts. Among these are:
- Shoot thinning in spring
- VSP training to create 2-dimensional trellis (especially for *V. vinifera*)
- Leaf removal in the fruit zone (by hand or mechanized) to improve exposure of fruit to good air circulation, sunlight and pesticide deposition
- Good weed control to limit humidity in the vineyard
- Nutrient management (nitrogen) to limit canopy density

- Eliminate any and all shading from trees. Shading from trees will create a 'hot spot' of mildew and every other fungal disease, that can spread to the rest of the vineyard.

Chemical control:
- Old standards: Sulfur, copper/lime, lime sulfur
- Sterol inhibitors (SIs; FRAC 3): Rally, tebuconazole products, Procure/Viticure/Trionic, Mettle, Difenoconazole products, Rhyme/Topgard EQ, Cevya
- Succinate dehydrogenase inhibitors (FRAC 7): Endura, Luna Experience/Sensation, Aprovia/Aprovia Top, Miravis Prime
- Quintec (FRAC 13), Vivando (FRAC 50), Torino (FRAC U6)
- Gatten EC (FRAC U13): ***NEW!***
- Alternatives/Biorationals: PolyoxinD Zn salt, Potassium bicarbs, Oils, Biologicals, Plant extracts, Monopotassium Phosphate (Nutrol)
- Strobilurins (FRAC 11): Abound, Sovran, Flint, Pristine, are **no longer recommended for powdery mildew control due to widespread resistance in eastern vineyards.**

Downy mildew of grapes

1. **Biology/epidemiology on grapes**

Downy mildew is caused by the microorganism *Plasmopara viticola* (not a true fungus…but who cares?) Unlike the powdery mildew pathogen, this pathogen is very dependent on rainfall/wet plant surfaces for infection: it only causes disease in wet climates and does not generally occur in dry, Mediterranean climates. The symptoms of downy mildew are the presence of bright, white, downy sporulation of the pathogen on clusters, shoots, and undersides of leaves. The pathogen overwinters as weather resistant, dormant structures (oospores) that release spores (sporangia) during spring wetting events of at least 0.1" rain and an average temperature of at least 52^{o} F. These wetting events generate primary infections that lead to repeating secondary cycles of the disease. The first infection cycles occur at about the time that vines average 5-6 leaves per shoot (generally 2-3 weeks before bloom?). Leaves are susceptible all season, though they do become more resistant as they age. Fruit are susceptible from capfall (beginning of bloom) through 2-4 weeks post bloom. Cluster stem tissue can become infected before bloom (causing loss of inflorescences) and may remain susceptible for another couple weeks AFTER fruit are resistant and can still lead to crop loss in mid/late July. Native grape varieties are least susceptible, *Vitis vinifera* is most susceptible, and hybrids are of variable susceptibility.

2. **Control of downy mildew**

Cultural control It should be noted that in wet climates (like that of New Jersey) and especially in wet years, cultural control will improve the effectiveness of a chemical control program but will not provide all the measures needed to control this disease, especially in a wet year, and especially on *V. vinifera* and susceptible hybrids. Here are a number of cultural practices that can be integrated into chemical control programs. Many are the same as for powdery mildew.
- shoot thinning in spring
- VSP training to create 2 dimensional trellis
- fruit zone leaf removal (manual, mechanized)
- light cultivation to bury overwintering inoculum
- early sucker growth control.

Chemical control

- Old standards: Copper/lime, mancozeb products, ziram, captan
- Ridomil (FRAC 4): Ridomil Gold Mz, Ridomil Gold Copper
- Gavel (FRAC 22 + mancozeb)
- Revus/Revus Top (FRAC 40)
- Ranman (FRAC 21)
- Phosphites/Phosphorus acid (FRAC 33)
- Zampro (FRAC 40 + 45)
- Alternatives: LifeGard, a biological pesticide (*Bacillus mycoides*) that has achieved good results in trials at Cornell University.
- Strobilurins (FRAC 11): Abound, Sovran, Pristine. Resistance is widespread and we are **no longer recommending their use for downy mildew control in many parts of the east.**

Session 3

Agronomy/Wildlife Damage to Agricultural Crops

Session Chair:
Stephen Komar

BEAR DAMAGE TO AGRICULTURAL CROPS IN NEW JERSEY

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Black bear (Ursus americanus) populations have been steadily increasing in New Jersey since the 1980's. Current research estimates the bear population between 3,000-4,000 bears in the prime bear region of northwestern New Jersey. This region is also home to a great deal of rural and agricultural land. Although anecdotal evidence suggests that damage to agricultural crops has increased, limited studies have been conducted to quantify bear damage in New Jersey agricultural crops. A research trial was conducted using two different technologies to quantify bear damage and to determine the spatial distribution of bear damage in corn. Bear damage was quantified using hand-held Global Positioning System technology in 2007 and by using aerial drone technology. In 2007, damage was found to be variable ranging from less than 1% of the total field area to nearly 8% with an average loss of 2.24% in 2007. Numerical differences were observed in the linear distance from individual bear rolls to forested areas with approximately 80% of the damage occurring between 25 and 200 feet. In 2021 and 2022 several fields were flown using aerial drones equipped with hi-resolution cameras. The drones were very effective to assess bear damage to agricultural crops and allowed for much faster field assessments with reduced labor.

In 2022, a grower survey was initiated to assess agricultural producers' views on crop damage from bears, potential solutions, and specific needs related to wildlife damage to crops.

Bear damage in agricultural crops can impact yield and ultimately profitability for agricultural producers in northwest New Jersey. Wildlife damage to crops is variable by field and several factors such as weather, crop load, availability of mast crops or other available foods will change the impact wildlife has on crop yield. More research is needed to determine spatial distribution of bear damage and to quantify the relationship between bear population, crop damage and to quantify economic losses due to wildlife damage.

Session 4

Sweet Corn

Session Chair:
Kate Brown

THE CHANGING LANDSCAPE OF CORN EARWORM MANAGEMENT
A 10-YEAR REVIEW

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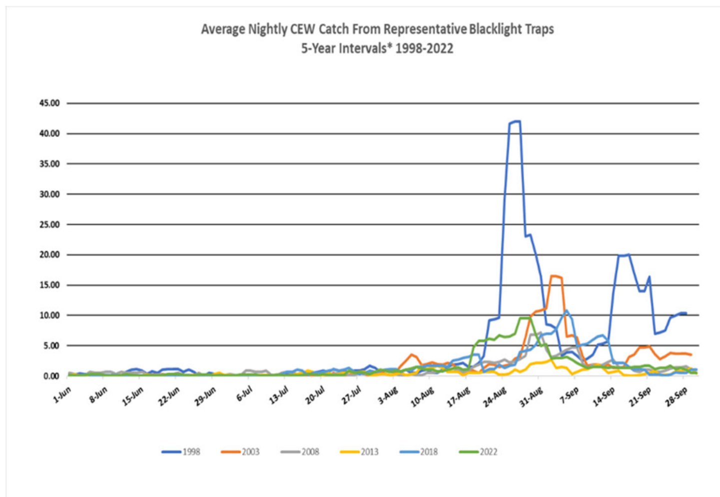
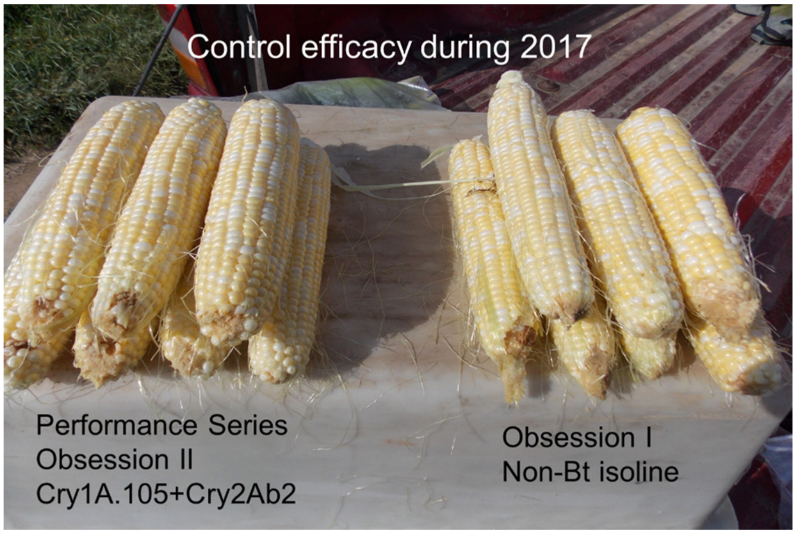


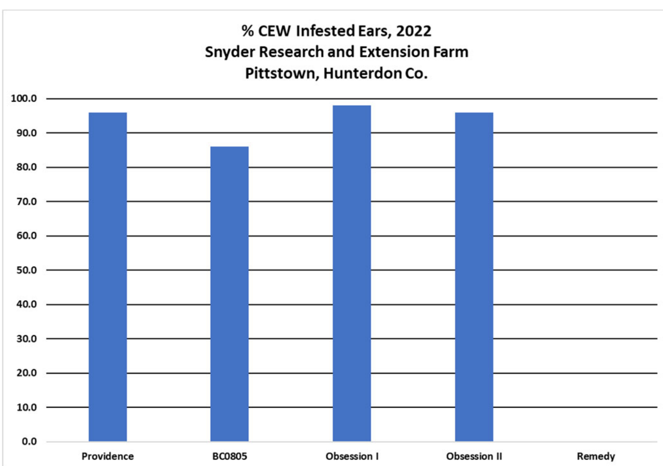
Corn earworm (CEW) moth populations have declined in recent decades, as demonstrated by falling blacklight trap catches **(right)**. This decline began in the late 1990's, with the advent of *Bacillus thuringiensis* (*B.t.*) transgenic host crops (field corn, cotton) of the corn earworm. Since that time, CEW populations in NJ have stabilized to a large degree, with year-to-year fluctuations. The past five years have seen higher catches in individual traps, but nothing to indicate a population scale increase in this pest.

Despite a lower population, CEW remains the most significant threat to sweet corn production in our area. While this is largely due to its' reproductive strategy of laying individual eggs on discrete ears, other factors starting prior to- but continuing into the past 10 years have made CEW management an expensive and often difficult problem. Chief among these is resistance to crystalline (Cry) toxins in *B.t.*, and to pyrethroid insecticides. We first need to look beyond ten years ago to know how we got here.

Through the 70's and 80's, organophosphorus (Insecticide Resistance Action Committee Group (IRAC) 1B)) and carbamate insecticides (IRAC 1A) were mainstays of CEW control in sweet corn. Synthetic pyrethroid (IRAC 3A) materials became dominant through the late 80's and early 90's as previous insecticidal classes were discontinued. Pyrethroid insecticides were very effective against CEW, and the availability of generic versions of popular products made this class economical for sweet corn production.

In 1996, field corn and cotton (both major CEW hosts) hybrids incorporating Cry I toxin from *B.t.* were available for production in the U.S. Both crops express low-dose levels of the toxin. In the early 2000's, Cry I toxins were made available in a few sweet corn varieties, with toxin expression at higher levels than the field crops. Initial efficacy on CEW was excellent, but by 2005 failures in sweet corn were evident. By 2015, Cry I toxin expressing sweet corn varieties did not offer any advantage over their non-genetically engineered analogs. A second type (Performance Series) expressing Cry I and Cry 2ab2 toxins was introduced in 2010, but by 2016 no longer offered realistic protection from CEW infestation **(photo at left)**. With both field corn and cotton expressing Cry toxins in much of the CEW overwintering areas (U.S. south of Maryland), there was ample opportunity for CEW to develop resistance to those toxins. At the same time, pyrethroid insecticides were, and continue to be widely used on Cry toxin expressing cotton in the U.S. because CEW that are resistant to Cry toxins have fitness issues (slower development, lower weight, etc.) and are more responsive to pyrethroids as a result. Intensive use of pyrethroids in cotton and soybeans in the southern U.S. are likely the cause of the pyrethroid resistant moths we have seen with increasing frequency in our area over the past 10 years. In 2014, Syngenta introduced the Attribute II sweet corn ('Remedy'). This corn, expressing the vegetative insecticidal protein (Vip3A) from *B.t.* in addition the Cry1A toxin has retained its' efficacy against CEW infestation in sweet corn through 2022 **(left)**.



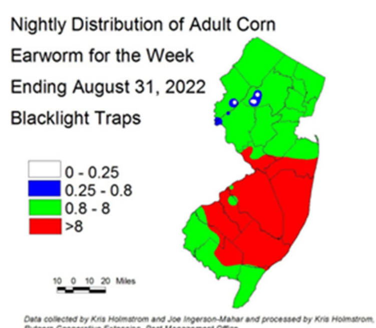


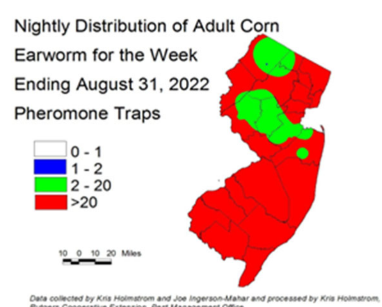
It is important to note that CEW doesn't reliably overwinter in New Jersey. Because of this, individuals that are resistant to Cry toxins or pyrethroids have little chance of passing on those traits to following generations. It should be clear then, that resistance does not develop here in NJ. It develops in places where overwintering occurs (southern U.S.) and affects us as CEW migrants arrive. Furthermore, sweet corn acreage is extremely small relative to field corn and cotton acreage, so there is no real chance of NJ sweet corn growers increasing the levels of Cry toxin or pyrethroid resistance due to their choices of control tactics. We must adapt to changes that develop to our south.

In the past 10 years, we have seen little change in CEW susceptibility to Cry 1 toxin. It had failed prior to this period. However, resistance to the Cry2ab2 toxin has increased, and the incidence of pyrethroid resistance has increased. At the same time, newer insecticide chemistries began to dominate the sweet corn market. The spinosyn class

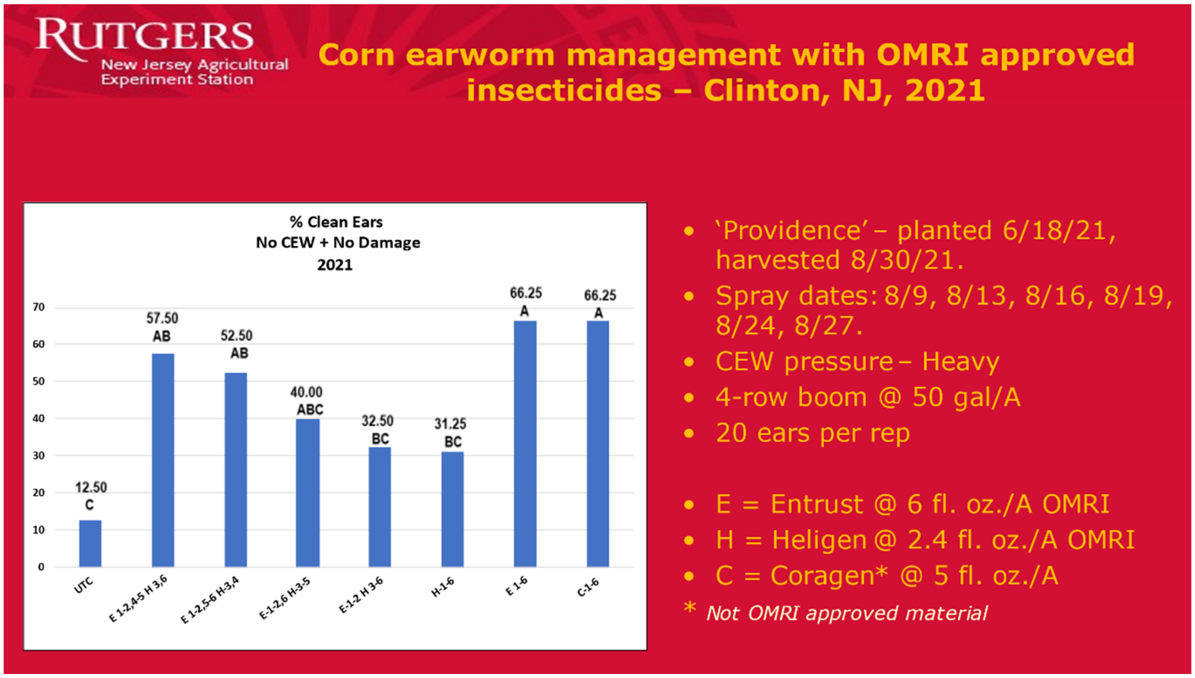
(IRAC 5) and the diamide class (IRAC 28) are primary examples. Despite increased cost for these products, they have largely replaced stand-alone pyrethroid applications for CEW control. The proprietary combination of the diamide material, chlorantraniliprole and the pyrethroid lambda-cyhalothrin is often among the most effective sprays in trials and has become a mainstay in NJ sweet corn production. Rotational products include spinosyns and the remaining carbamate material methomyl.

Effective insecticide use is critical to CEW control, but indiscriminate use of insecticides increases cost of production, and is often harmful to beneficial insects that provide pollination and pest reduction services. Therefore, decision making (IPM) is the other key factor in control. The current system for providing up-to-date CEW information to growers and the wider ag services community involves a statewide network of blacklight traps **(top, left)** and a smaller network of CEW pheromone traps **(lower left)**. Information from these networks informs participating growers as to the CEW situation and suggested spray schedules on their farms. Additionally, information from the trap networks is processed weekly to create interpolated surface maps **(below)** of CEW moth activity in NJ as part of the Rutgers Plant and Pest Advisory. Interpolated maps use data from discreet trap sites to estimate activity between the sites. This information is made available to all interested parties each week but is time consuming to produce and has no historical component. CEW population trends are described in the text associated with the maps. There is a movement among east coast university entomologists to develop a regional, interactive pest mapping program for sweet corn pests, including CEW. This type of program is in development and would include the ability for users to access data from specific trap sites to get historical data, as well as see CEW moth movement across the region. New Jersey is the only state in the Northeast or Mid-Atlantic regions that still utilizes blacklight traps for CEW monitoring. Because blacklight data will not integrate well with regional pheromone trap derived data, New Jersey will likely place more emphasis on pheromone trapping for decision-making, enabling us to participate in a wider monitoring scheme.





With limited insecticidal options for CEW control, ongoing trials with novel insecticides are taking place. In New Jersey, a viral-based product specific to CEW was investigated in 2021-22. Other states have also trialed biological, or bio-based products



to find ways to fit them into existing control programs. Under heavy CEW pressure, NJ data show that the OMRI approved viral product Heligen®, used minimally to separate applications of the OMRI approved spinosyn Entrust, provide levels of control on par with Entrust used alone (spinosyns are not recommended for use more than twice consecutively). In an organic system, this may be good enough to allow for reasonable sweet corn production. In other systems, the hunt goes on to see if combinations of biologicals with conventional insecticides improve/maintain control of CEW.

As we move into the next decade growers should anticipate the most changes to occur in the areas of monitoring and information dissemination. Proposed studies include identifying the optimal design of CEW pheromone traps, as well as lure components; identifying the origin of flights to anticipate rates of pyrethroid resistance in migratory populations; integrating all Northeast and Mid-Atlantic trap networks into a single interactive web-based information system that all interested parties may access. Ongoing resistance monitoring for the Vip3A toxin will continue in hopes that the Vip3A trait does not lose efficacy through poor resistance management as was the case with Cry toxins.

<u>Session 5</u>

Nursery I

Session Chairs:
William Errickson

NATIVE TREES FOR LOW INPUT LANDSCAPES

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"A keystone species helps define an entire ecosystem. Without its keystone species, the ecosystem would be dramatically different or cease to exist altogether." – National Geographic

Many of the native tree species that are currently being grown and managed in the nursery and landscape sectors are keystone species. Keystone species perform essential ecological functions that support higher levels of biodiversity to a greater degree than other plant species. These trees can have a dramatic effect on enhancing their surrounding ecosystems, including supporting pollinator and bird populations. However, these important trees each have specific site requirements and pest and disease issues that may require management to reach their full potential. As such it is important to take an Integrated Pest Management (IPM) approach to growing and maintaining native trees in our region, with an emphasis on reducing impacts on beneficial insects.

IPM Approach

- Step 1. Monitor and scout insects to determine insect types and population levels
- Step 2. Identify the pest and host accurately
- Step 3. Assess and consider economic or aesthetic injury thresholds
- Step 4. Implement a treatment strategy using mechanical, cultural, biological, or chemical controls, or a combination of these strategies
- Step 5. Evaluate the success of any treatments

Oaks (*Quercus* spp.) are keystone species with a high level of ecological benefit. They serve as host trees for over 500 different species of native moths and butterflies and support populations of birds and other wildlife. Oaks have a long lifespan (100-200+ years) and can help to stabilize soil, sequester carbon, mitigate air pollution, and produce shade. NJ Has 17 different species of native oaks that are adapted to varying site conditions. Northern red oak (*Q. rubra*) is the NJ State Tree and can be used as a shade tree or street tree in urban, suburban, or rural landscapes. It is relatively fast growing (for an oak) and requires full sun and well-drained soil. Swamp White Oak (*Q. bicolor*) is another species that is very adaptable and is a good choice for urban sites. It tolerates soil compaction and wet sites but is also drought tolerant.

Scale insects, including Lecanium scale (*Parthenolecanium quercifex*), Obscure scale, (*Melanuspis obscura*), and Golden oak scale, (*Asterolecanium variolosum*) can cause damage to oak trees and many other native trees over time. These insects can be especially damaging to young trees in a nursery setting. Avoiding overfertilization and reducing moisture stress will help to prevent scale outbreaks. There are numerous beneficial predators and parasitoids that can help keep scale populations low. Control measures should target the vulnerable crawler stage to be most effective.

Oaks can also be susceptible to Bacterial Leaf Scorch (BLS) caused by the pathogen (*Xylella fastidiosa*). This bacterium is transmitted by xylem-feeding insects and results in leaf scorching. This is caused by low-level moisture stress that occurs as xylem vessels in the leaf veins become blocked by the bacterium. Symptoms typically appear in mid to late summer on lower branches as irregular marginal browning on lower and interior leaves. There is no cure and few practical controls for BLS. Best management practices involve minimizing moisture stress, maintaining fertility, and proper pruning. Red oaks tend to be more susceptible to BLS, so other oak species may need to be considered if planting in an area that has a history of BLS damage.

Native *Prunus* species, including black cherry (*P. serotina*), chokecherry (*P. virginiana*), and American plum (*P. americana*) are another important keystone tree species in the Mid-Atlantic region. These trees produce flowers that provide nectar and pollen for many species of pollinators and beneficial insects. The fruit produced by these trees also feeds many native birds and other wildlife. Native *Prunus* trees attract 414 different species of moths and butterflies which further help to support bird populations and promote biodiversity. These trees generally require well-drained soils and full sun to reach their full potential and to minimize any insect or disease issues.

One very common disease on *Prunus* is black knot, caused by the pathogen *Apiosporina morbosa*. This fungus causes galls to form on the trees, which can girdle the branches, causing leaves to wilt and die. Frequent monitoring and early scouting will help to identify this pathogen before it spreads throughout the tree. The galls can be pruned out in late winter/early spring. In a nursery setting, it may be necessary to apply protectant fungicides when flower buds start to open in the spring if black knot has been a common problem in previous years.

Birch (*Betula spp.*) include several native species of trees, including sweet birch (*B. lenta*), gray birch (*B. popufolia*), and river birch (*B. nigra*). Birch trees perform many important ecological functions and support over 350 species of native moths and butterflies. Birch trees can be an excellent addition to low-input landscapes if they are planted in the right growing environment.

The bronze birch borer (BBB) (*Agrilus anxius*) can be a major pest of birch trees and tends to attack trees that are already suffering from another stress, especially drought. Long-term research has shown that native birch trees were more resistant to the bronze birch borer than non-native birch species. Furthermore, the study found that birch trees under drought stress (1/2” irrigation per week vs. 1” irrigation per week) were more susceptible to BBB damage. Overall, native river birch was the most resistant species when provided with adequate soil moisture.

Native maples (*Acer* spp.) including red maple (*A. rubrum*), silver maple (*A. saccharinum*), and sugar maple (*A. saccharum*) are widely adapted to many low-input landscapes. Maples support 286 species of butterflies and moths, and their flowers are a great early season pollen and nectar source for beneficial insects. While silver maple is a fast-growing option for a shade tree in residential environments, its large root system has been known to disturb sidewalks, foundations, and underground pipes. As such, care must be taken to properly locate these trees away from infrastructure that might get damaged. For urban environments, a recent study found that red maple actually grew better in a heavily urbanized city compared to a slightly urban locality. It was suggested that the additional heat and carbon dioxide in the heavily urban area created increasingly favorable growing conditions for the trees that were observed.

Native trees can provide aesthetics and ecological benefits to many different landscapes in our region. By selecting the right species for the right location, and following the principles of IPM, these keystone species can provide important ecosystem services for many years.

Resources

Native White Birches & Their Resistance to the Bronze Birch Borer
https://plant-pest-advisory.rutgers.edu/native-white-birches-their-resistance-to-the-bronze-birch-borer/

Study finds that red maples were more productive in an environment with more urbanization
https://phys.org/news/2020-10-red-maples-productive-environment-urbanization.html

CONSIDERATIONS ON IRRIGATION MANAGEMENT OF NURSERY CROPS

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Water is essential to life on this planet. In the case of plants, it constitutes from 70 to 95% of their herbaceous (non-woody) fresh biomass (weight). In addition to its contribution to these herbaceous tissues (leaves and young-soft shoot and root tissues), water transports minerals and metabolites through cells and tissues, and along with these solutes, provides the positive pressure, or turgor, against cell walls, which is the main driver of plant growth through cell expansion (Hsiao, 1973). Thus, any reductions, even if temporary or short term, in the availability of water to plants and crops lead to loss of turgor (eventually wilting) which almost immediately reduces or impairs a plant's growth and critical biological functions like protein synthesis and photosynthesis.

Interestingly, while water constitutes the largest fraction in herbaceous tissues, only a small fraction (as low as 1%) of the total water absorbed by a plant through its entire life is retained in this biomass, and the rest 'lost' through transpiration. This is appreciated in the water use efficiency (WUE) concept, defined as the unit of plant biomass (grams or pounds of fresh or dry weight) produced per unit of water applied/used (like liters or gallons). For example, roses growing in containers with peat substrates, fertigated with solution applied directly to the substrate (with spray stakes), are reported to have an annual WUE of 0.7 to 1.8 grams of dry weight per liter of water applied, equivalent to 0.10 to 0.24 oz. per gallon of water applied (Cabrera, 1997; Raviv and Blom, 2001).

Water supplies that maximize transpiration lead to maximum growth
The apparently inefficient use of water by plants – relatively low WUE – is a consequence of the leaves opening their stomata (specialized opening on leaf surfaces) to capture CO_2 to do photosynthesis. This opening also leads to loss of water (i.e. transpiration) which facilitates uptake and transport of nutrients from the soil, and helps control the plant's temperature by cooling its leaves during this transpiration process.

It has been shown that the maximum efficient use of water by crops, the one that results in maximum crop growth/yield, occurs when water is freely available or provided without restrictions to plants through the growing season, and transpiration is allowed to continue at its maximum potential rate (Hanan, 1998). Therefore, any factor(s) that restrict the supply of water or its uptake by plants will reduce its transpiration, and thus it will proportionally reduce its biomass (weight or volume produced over a defined growing period). This is exemplified in Figure 1, with some WUE results from substrate (container)- grown roses over a one year growing period. In a nutshell (an over-simplification of), the data shown in this figure indicates that the more water the rose plants transpired (evapotranspiration), the more growth they produced (harvested flower biomass) over the course of one year.

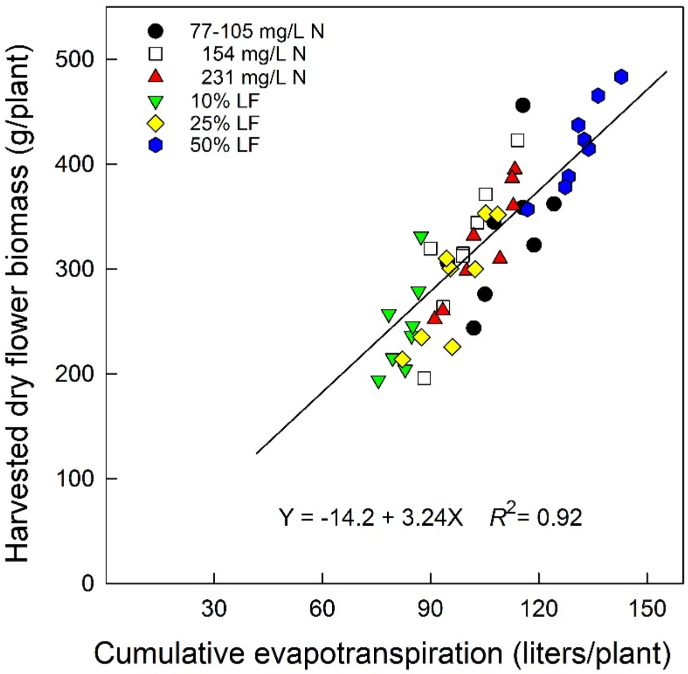

Figure 1. Relationship between cumulative evapotranspiration and biomass of harvested flowers from container-grown rose plants fertigated for one-year nutrient solutions varying in applied nitrogen (N) concentration and leaching (drainage) fractions (LF). From Cabrera (2021).

Water status in soils/substrates and its effective availability to plants.
The effective availability of water in the rootzone of plants, in both soils and substrates, and its uptake and movement through the plants and loss by its leaves to the air (the soil-plant-atmosphere continuum, SPAC) is theoretically described by the concept of water potential, Ψ (Raviv and Blom, 2001). This is defined as the potential energy of water in any SPAC compartment, expressed as energy per volume (pressure), in comparison to pure water, whose value is set at 0 kPa or MPa (kilo-Pascal or Mega-Pascal, units of pressure). Thus, the total water potential (Ψ^{Total}) values measured at any SPAC compartment will be negative (lower than 0). The Ψ^{Total} is composed of the algebraic sum of various factors as described in the following simplified equation:

$$\Psi^{Total} = \Psi_m + \Psi_o + \Psi_p + \Psi_g$$

Where Ψ^{Total} = overall water potential in soil/substrate, plant tissues or air; Ψ_m = matric potential; Ψ_o = osmotic potential; Ψ_p = pressure potential; Ψ_g = gravitational potential. The Ψ_m defines how tightly water is retained by the soil or substrate particles, and can be measured directly with a simple and inexpensive tensiometer. The Ψ_o can be directly calculated by just knowing the total concentration of soluble salts in a soil/substrate (and even in plants tissues). The Ψ_g can be calculated by just knowing the height or distance of a plant organ, like a leaf, to the surface of the soil. The Ψ_p is often calculated by difference (if we know the other Ψ factors). In general, water in the SPAC moves down a gradient, namely from a zone with a higher (less negative) total water potential (Ψ^{Total}), like the soil/substrate, to one with a lower (more negative) Ψ^{Total}, like the air.

From a crop management point of view, the impact of the Ψ of the soil/substrate (Ψ^{soil}), dictated by the Ψ_m and Ψ_o components, on crop growth/yield is largely and directly affected by the growers' actions on water and fertilizer applications.

Assuming the soil/substrate has good aeration, the maintenance of a high Ψ_m (less negative, closer to 0) by frequent irrigation, has been reported to produce the largest growth and yields in woody and herbaceous ornamental plants (Hanan, 1998). For example, in roses growing in sandy soils or peat-based substrates, their largest flower yields are observed when Ψ_m are maintained in the −5 to −20 kPa range (Lieth and Oki, 2019). This supports the observations of, and recommendation for, cyclic irrigation in container nursery-crops, where multiple applications of small volumes of water result in larger plants than single irrigation applications with large volumes (Bilderback et al., 2013). In other words, the more extended the dry-downs of the soil or substrate between irrigation events, resulting in lower (more negative) Ψ_m (like approaching -50 kPa or more negative), the less the resulting growth.

The Ψ_o describes the forces between dissolved particles (mainly nutrient salts in their ion forms) and water molecules. The Ψ_o of pure water is 0, and if a solution has any solutes (ions/salts), their concentration defines how negative it becomes. The Ψ_o is easily calculated by just knowing the concentration of soluble salts. In irrigation water or fertilizer solutions, and in the water in the pores of soils/substrates (*aka* soil solution) this is quickly and inexpensively measured with an electrical conductivity (EC) meter. The Ψ_o of any water or solution is calculated with the formula: $\Psi_o = -36 \times EC$, with Ψ_o and EC expressed in kPa and dS/m, respectively (Lieth and Oki, 2019).

Using this simple formula, we see that a typical fertigation solution with an EC of 1.8 dS/m results in an Ψ_o of −62 kPa. In the case of soils fertilized with granular fertilizers, or containerized substrates with controlled-release fertilizers (CRF), we often extract the soil solution to measure its EC. A typical soil solution extract with an EC of 3.0 dS/m will result in an Ψ_o of −104 kPa. These fertigation and soil solution EC values denote the salinity threshold (maximum limit) for many ornamental and flower crops (Cabrera, 2021). Notice how the osmotic potentials calculated from these EC values are more negatively larger than those from the matric potential (Ψ_m) range (−5 to −20 kPa) associated with maximum rose crop growth. Considering that the total water potential (Ψ^{soil}) of the water in the soil or substrate is mostly defined by the algebraic sum of Ψ_m and Ψ_o, we thus see that the Ψ_o resulting from the applications of fertilizers (whether liquid, granular or CRF) will likely contribute more significantly to the Ψ^{soil} in the rootzone than trying to irrigate more frequently to maintain low (less negative) Ψ_m. The more negative the Ψ_o the more negative the total Ψ^{soil}, thereby reducing both theoretically (in physico-chemical terms) and in practice its availability for potential uptake by the plants. Many growers might have observed plants wilting in the presence of adequate moisture in the soil/substrate (high or less negative Ψ_m values), but upon measuring the soil solution or drainage water they observe high ECs (like over 5 dS/m in salt-sensitive species like azaleas or other acid-loving plants).

The effects of moderately high EC and Ψ_o in the soil solution, even in transient or short-lived occurrences, can quickly and significantly impact the expansive growth and elongation of young plant stems (Hsiao, 1973). For example, cut flower roses growing in coconut coir were fertigated with a nutrient solution that maintained the substrate EC at

1.0 dS/m, and were exposed to a brief 2-hr period with the same solution supplemented with NaCl salt to raise the substrate EC to 2.8, 4.7 and 7.6 dS/m (equivalent to Ψ_o of -100, -170 and -275 kPa, respectively). The flower stem elongation rates were measured continuously (every 6 seconds) over this short experimental period, averaging 1.0 mm/hr (0.04 inches/hr) in the control plants with the substrate EC of 1.0 dS/m. Within 15 minutes of applying this brief (2-hr) salt stress producing substrate ECs of 2.8, 4.7 and 7.6 dS/m, reduced the stem elongation rate by 13%, 28% and 79%, respectively (Oki and Lieth, 2004). Interestingly, the shoot elongation rates in the salt-stressed plants resumed their previous average value of 1.0 mm/hr (0.04 inches/hr) within 2-3 hours after removal of the supplemental NaCl stress by applying a leaching equivalent to 1.5X the substrate's volume (12 liters of base 1.0 dS/m nutrient solution). These results strongly support the longstanding recommendation to frequently monitor and limit the EC in the rootzone of ornamental plants/crops to <3.0 dS/m (Cabrera, 2021).

Take home message: A systematic monitoring of Ψ_m and Ψ_o, easily measured or calculated from values from simple and inexpensive instruments like tensiometers and EC meters, can help growers track the status of crop water availability (tracking the total Ψ^{soil}). These values can and should be used to make rational decisions on how to manage both irrigation and fertilizer applications, increasing their use efficiency and leading to maximum crop growth/yields.

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PROMOTING BACKYARD BENEFICIALS

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Too often, landscape plant managers ignore or confuse beneficial organisms with insect pests and inappropriately apply control materials. This is especially the case with the larvae or immature stages of beneficial insects. An observant and knowledgeable IPM scout needs to learn how to recognize and conserve these “good guys,” so they are not needlessly destroyed. Remember, *“we must look before we shoot,”* when spraying pesticides, and take advantage of natural pest control that works for free!

The classical definition of biological control is the use of natural enemies to control insect pests. These natural enemies include predators, parasitoids, and pathogens. Pathogens are microorganisms (bacteria, viruses, fungi, protozoans, and nematodes) that kill pests. Parasitoids are parasites that kill their hosts through their feeding activities. Most parasitoids of landscape pests are wasps and flies. **This presentation will primarily discuss some of the more valuable ornamental landscape predators & parasitoids.**

PREDATORS

The most common insect predators typically encountered in the urban landscape are lady beetles, lacewings, and flower flies. These insects are usually, but not always, larger than their prey. They are active and fast-moving since they must hunt and capture other insects to survive. Each of the three predator types listed above must consume a lot of prey to complete their life cycles. With some species, hundreds of individual prey hosts must be consumed before the development of the predator can be completed. Although technically not insects, another common but excellent “backyard beneficial” are predatory mites species contained within the family *Phytoseiidae*.

Lady Beetles

Lady beetles have been incorrectly called ladybugs by so many, for so long, that this common name has become accepted, except by entomologists. We have all been able to recognize the adult stage since we were kids, but there are still too many of us who cannot identify the larva stage of the lady beetle. The larvae are 1/8” to ¼” long and are elongated in shape. The segmented body tapers from the front to the back end with many body segments containing spines. The color is variable, often showing bright yellow to orange markings, with a black background. The larger and more brightly colored larvae are those species that feed most heavily upon aphids. Alternatively, the smaller, darker, and less colorful larvae are species that feed primarily on scale insects.

The eggs can be up to 1/8” long, are elongated oval, and yellow or white. Easily observed by those with a keen eye, they are mostly seen as yellow eggs laid on end in clusters of 10 to 20. Single, white eggs are laid by lady beetle species that prey upon scales and mites.

The most common prey of lady beetles are aphids, scale insects, and spider mites. Since the larval stage of the lady beetle feeds most voraciously upon its prey, it is important to identify this predator. Research has shown 3 to 4 larvae controlling over 300 aphids per 2-foot branch terminals on apple trees. However, when all prey is consumed, lady beetle larvae may turn cannibalistic and devour one another. Although this behavior limits some potential benefits, it ensures that some individuals will have enough prey to develop to become adults and reproduce to create the next generation. If there is not enough prey to supply another generation, the second-generation adults will then leave that area without laying eggs. Once autumn temperatures consistently drop below 65°F. most lady-beetle adults will stop their activity and search for protected overwintering sites.

Do not always expect outstanding results by purchasing lady beetles from catalogs (often collected in California) and releasing them in the Northeast to provide pest control for landscape ornamentals. They may not find the proper conditions for feeding and egg production, and therefore, will provide little to no value. Plus, they typically fly away upon release! Simply conserving the activity of those naturally present can provide meaningful pest control for outdoor ornamental plants.

Lacewings

The larvae of lacewing insects are some of the most useful beneficials found in the landscape. These voracious creatures are sometimes called aphid-lions and have been described as the "*psychopaths of the insect world*," because they are truly "killing machines." The larvae are 1/8" to 3/8" in length, have a flattened elongated shape, and are drab brown to gray. They have large, deadly fang-like mandibles that are used to impale their victims to suck out body fluids.

Lacewings can often be found attacking prey larger than themselves and appear to have insatiable appetites. One larva, for example, may eat 1,000 spider mites a day for 15 days. Observations in apple orchards have shown that lacewing larvae have controlled apple aphids at a ratio of 1 to 70, and at rates of up to 60 aphids per hour (Note that if this ratio reaches a 1 to 150 level, the predator is overwhelmed, and suppression is not achieved). Lacewings prefer mostly soft-bodied insects such as mealybugs, scale insects, whitefly, and the eggs of caterpillars and thrips.

Lacewing eggs are oval, and white and are laid on long delicate stalks in groups or individually. The eggs are placed on the ends of the stalks to reduce cannibalism from siblings. Eggs hatch after 6 to 14 days. Since this egg-laying appearance is unique within the landscape, they are easily identified when monitoring. After egg hatching the larvae feed for 2 to 3 weeks before they spin whitish, pea-sized cocoons and pupate while attached to a leaf. The last generation of the season will overwinter as cocoons in the pupal stage.

The adults of lacewings are weak flyers with fragile bodies and are not usually considered to be effective predators. The more common lacewing species in the landscape have greenish bodies, heavily veined wings, and are ½" in length. 'They primarily feed on honeydew, nectar, pollen, and aphids. Lacewing adults can live for 3 to 5 weeks. Although not great predators, the adult females of some species do require aphids as food to stimulate egg production.

Flower Flies

The flower fly (or *syrphid* fly) is an insect that many landscapers have seen but incorrectly identified as a type of wasp or bee. Their hovering flight and yellow to orange band markings on the abdomen help cause this misidentification. Although these beneficial insects are predacious only in the larval stage, they are another important group of predators that rival the abilities of lady beetles and lacewings. The larvae of flower flies are unknown allies to many landscape plant managers. It is rare not to find at least a few of these 1/8" to ¼' long tan or greenish maggots feeding within an aphid colony. The larvae also have black markings and pointed anterior and blunt posterior ends on their bodies.

These larvae will quietly meander over the plant surface methodically grasping one aphid after another. Once this predator spears an aphid with its pointed jaws (i.e., its mouthparts consist of 2 retractable hooks), it raises the prey into the air and sucks out the fluid contents. A flower fly can destroy aphids in this manner at a rate of one per minute over an extended period. It is also significant to note that they are usually the major predators in the fall season since they can function at cooler temperatures than lady beetles or lacewings. The flower fly larvae also prey upon leafhoppers, scales, mealybugs, and thrips.

The adults closely mimic the flight pattern of hummingbirds as they hover over flower heads. The adults-only feed upon pollen and nectar and are themselves valuable pollinators. Females require pollen from flowers or weeds before they can produce eggs. Adults often require the presence of a couple of dozen aphids per leaf before egg-laying will be triggered. The eggs of flower flies are flat, 1/8" long, whitish, and finely divided. These elongated eggs are laid individually and attached lengthwise on leaf surfaces among groups of aphids.

PARASITOIDS: (Wasp & Fly Parasites)

Within the landscape, beneficial parasitic wasps or flies are called "parasitoids." Within the landscape, approximately 2/3rds are wasp species while the remaining 1/3rd are species of flies. Unfortunately, parasitoids are often under-estimated because they are often capable of providing even better biological control than larger predators. In many situations, parasitoids will give superior suppression of pests because they: (1) are more host-specific; (2) have a better searching ability; (3) work at lower pest densities; (4) require less food to complete development; (5) are better synchronized to their hosts' life cycle, and (6) eliminate the hazards of host-seeking since eggs are laid in or on the host.

Since parasitoid adults are usually significantly smaller and less stationary than many of our well-known landscape predators, they often go undetected by landscapers. Since parasitoid larvae often develop inside the host, it is difficult to monitor and appraise their impact on a pest population. Monitoring adults within the landscape may not be practical, although yellow sticky traps can be attempted. More effective field evaluations can be made by observing host symptoms such as the swelling of aphids into mummies, the darkening of soft scale insects, and the exit holes in armored scale insect covers & exoskeleton of soft scales.

PREDATORY MITES

The family of phytoseiid mites is a diverse collection of the most abundant predatory mite species found in the landscape. The many species within this family are especially active during the summer months and are regularly found preying on two-spotted mites and other pest mite species. Like monitoring for pest mites, sampling for beneficial mites is most efficiently done by beating foliage over a hard white surface (= beating tray). This technique allows for the ratio of predator to prey to be directly observed. The standard action threshold of 20 pest mites per beating tray sample can be doubled when a few predatory mites are observed. It is advisable to perform weekly samplings to manage short-generation phytoseiid mites during warm weather.

Use a 10-15x magnifying hand lens when attempting to closely observe predatory mite eggs, larvae, nymphs, and adults. Phytoseiid mites' eggs are oval and larger than spider mite eggs. Within an infested spider mite population look for phytoseiid eggs laid singly along the veins on the bottom surfaces of leaves. All life stages of active phytoseiid mite species found in the landscape are oval, shiny, and similar in size to spider mites. They are easy to distinguish from spider mites because of their shiny, unspotted, pear-shaped, and mostly hairless appearance. The most dramatic difference between pest vs. prey mites is their speed of movement. As would be expected, predatory mites are many times faster than spider mites.

The life cycles of phytoseiid mites and spider mites closely resemble one another. Uniquely, phytoseiid mites in some cases can have a shorter time interval between generations than their mite prey. Also, they both lay about the same number of eggs (60) under average conditions over several days. However, predatory mite egg-laying rates will increase in response to larger prey populations. Phytoseiid mites will typically consume approximately 20 spider mites each, but some voracious species can gobble up over 100.

Reference: Syllabus of the Advanced Landscape Plant IPM Short Course, Volume III; John Davidson, Dept. of Entomology, Univ. of Maryland

Reference: Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control; Publication 3386, Statewide IPM Project, Univ. of California

Session 6

Integrated Pest Management

Session Chairs:
Kris Holmstrom
and
Joe Mahar

SMALL AND MITE-Y: MANAGEMENT CONSIDERATIONS IN VEGETABLES

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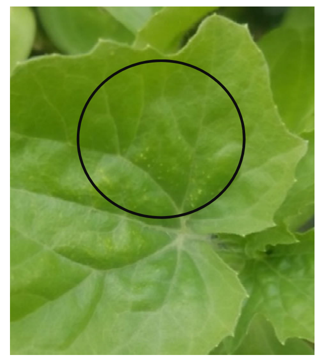
Two spotted spider mite, *Tetranychus urticae* Koch, is often thought of as primarily being a hot, dry-weather pest. During hot weather, spider mite reproduction is extremely rapid. However, spider mites can be problematic in vegetables even in average ore even wetter weather conditions. Factors that render a vegetable field extremely supportive of two spotted spider mite include black plastic mulch, frequent fungicide applications, high fertility, and frequent broad spectrum insecticide applications.

In Delaware, mites are a threat from June through the second week of August, after which their populations tend to rapidly decrease. Crops that are routinely affected include watermelon, tomatoes, and eggplants. Suggested action thresholds (for crops that have not been as extensively studied) and economic thresholds for mites in various vegetables are summarized in Table 1. In Delaware, watermelon is often treated 2-4 times per season for spider mites. Usually mites begin to appear around field edges in low numbers by early to mid June, but occasionally field-wide or extreme hot spots develop earlier, possibly as a result of infested greenhouses. Greenhouses should be maintained as weed-free as possible and transplants monitored for mite infestation prior to transplant.

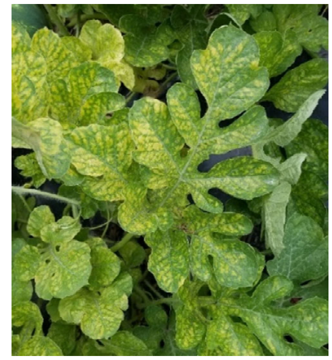


Young watermelon transplant infested with spider mites

Table 1. Economic and Action thresholds in extension and scientific literature for various vegetable crops

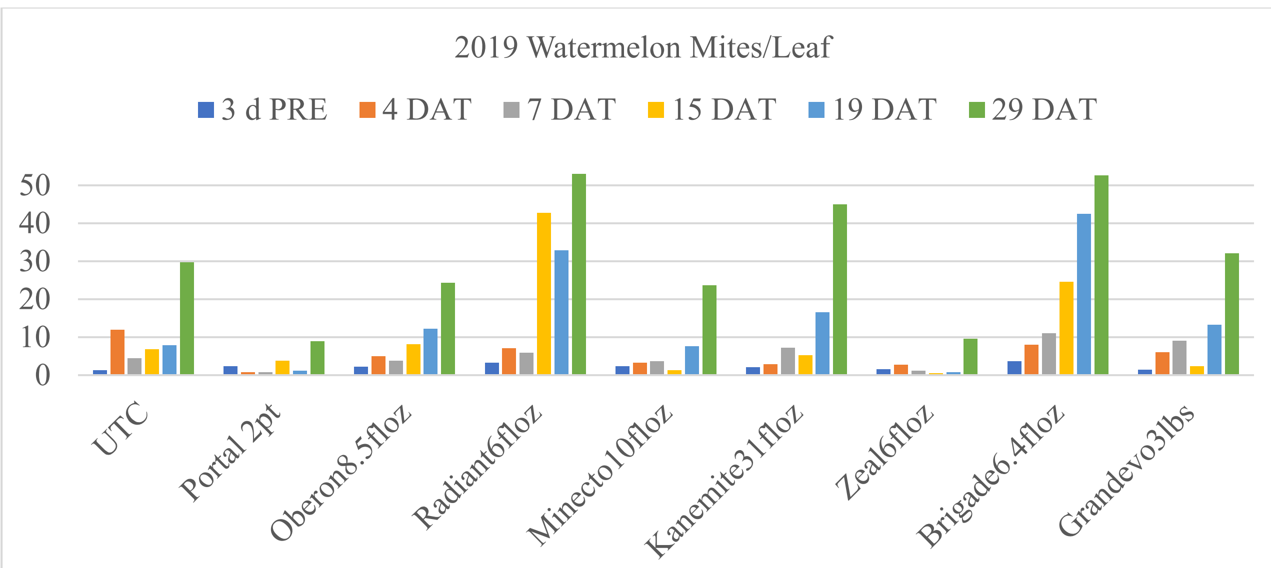
Crop	Action or Economic Threshold	Notes
Beans	20 mites/leaflet, early	UD extension recommendations
Eggplant	4-8 mites/leaf	Study on related *T. marianae* in Mariana Islands
Summer Squash	Early season 10-15% crown leaf infestation	Mid-Atlantic Production Guide
Strawberry	5 mites/leaflet pre-fruit 15 mites/leaflet fruiting	University of California
Tomatoes	4-8 mites/upper canopy terminal leaflet	NCSU research
Watermelon	20-30% crowns with 1-2 mites/leaf early; 50% terminal leaves late	UD extension recommendations

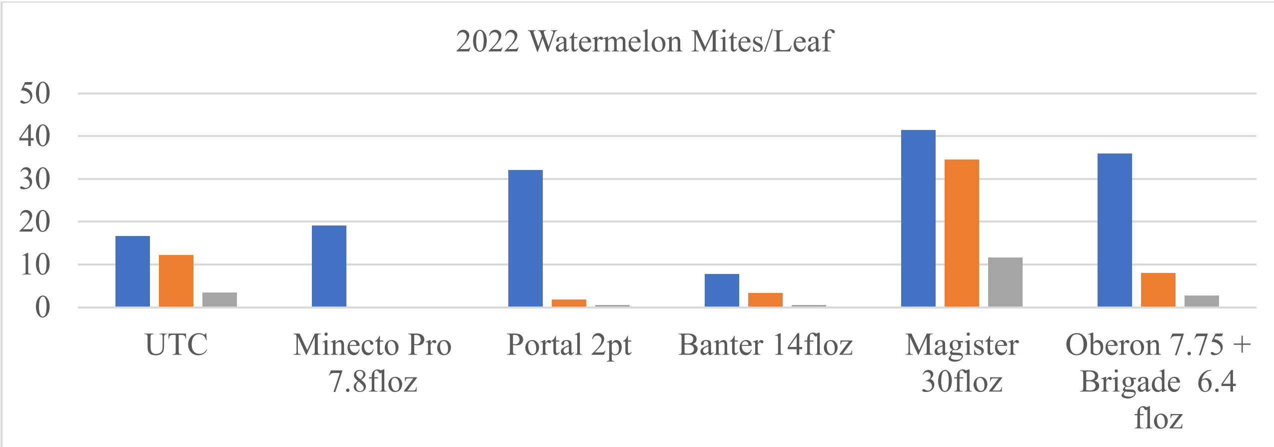
Magnification is extremely important when scouting for spider mites. On young, thin leaves, mite feeding can be visible without magnification and appears as small yellowish stipple marks. Older leaf tissue is thicker and discoloration might not be evident until a very large population has already developed. On older leaves, mite-induced discoloration can be confused with other disorders or diseases.



Heavily infested watermelon

Mite reproduction is extremely rapid in the summer, and in plot trials, populations can increase almost 10x in number of mobile mites in one week's time. High mite populations usually develop in conjunction with a fruit load when plants are under stress and can be exacerbated by previous use of broad-spectrum insecticides. In watermelon small plots, mite populations lead to reduced vine vigor and may impact yield, although we have not been able to determine the magnitude of this impact on final yield. There are numerous miticide modes of action to choose from. Abamectin (trialed as Agri-Mek SC and Minecto Pro) has been the most consistent miticide in UD spray trials, followed by fenazaquin (Portal). Miticide selection and spray trial results will be further discussed. Excellent coverage is extremely important for mite management. In addition to mites, non-target effects, particularly to pollinators and to natural enemies needs to be carefully considered.





Work has been done to look at releasing commercially available predatory mites to combat two spot spider mite. Predator selection can be important, especially with tomatoes. There is a long lag time which needs to be factored into decision making before a biological control agent is established to the point where it can exert control. Biological control experiments with watermelon have not yielded consistent results or mite control, but have shown very good promise in tomatoes. Biological control will be briefly discussed. A comprehensive spider mite fact sheet, with emphasis on biological and chemical control can be found at https://www.udel.edu/academics/colleges/canr/cooperative-extension/fact-sheets/two-spotted-spider-mite/.

DIAMONDBACK MOTH IPM INCLUDING ON-FARM MATING DISRUPTION TRIALS IN VIRGINIA

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Diamondback moth (DBM), *Plutella xylostella* (L.), is a major pest of brassica crops globally including the northeastern United States, where it has been established since the 1850s. DBM damage is caused by larval feeding on leaves as well as the presence of larvae or pupae in harvested produce (cabbage and broccoli heads etc..). DBM is notorious for rapidly developing resistance to insecticides, and populations have shown resistance to nearly 100 different insecticides globally, including 26 in the United States. In recent years, diamides, such as Coragen and Beseige (chlorantraniliprole), Verimark, Exirel (cyantraniliprole) and Harvanta (cyclanilprole), have been a popular group of insecticides for DBM management. Unfortunately, diamide-resistant DBM populations have been detected in most brassica production regions in the United States.

Despite DBM's history of developing resistance to insecticides, chemical control remains the primary management tool, even with organic producers who frequently use the biologically-derived insecticides *Bt* or Entrust (spinosad). However, natural biological control can play a huge role in suppressing DBM populations. A number of natural-occurring arthropods consume and/or develop on DBM eggs and larvae. For instance, in Virginia, the parasitoid wasp *Diadegma insulare*, parasitized from 25 to 100% of the DBM larvae collected from cabbage and broccoli fields around the state (Fig. 1).

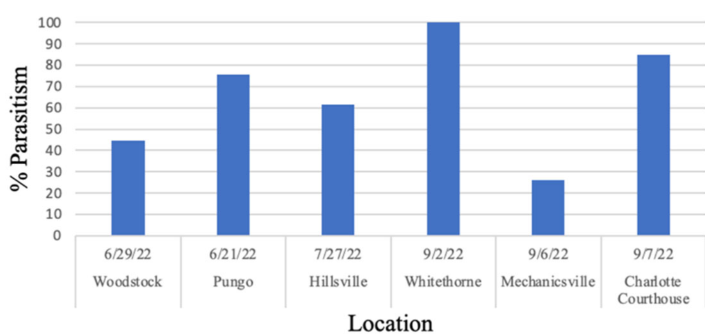


Fig. 1. Parasitism levels of DBM larvae collected from cabbage or broccoli in Virginia in 2022.

Thus, it is imperative that pest management strategies that conserve or enhance the action of natural enemies as well as reduce the selection pressure for insecticide resistance development be employed for DBM control programs.

Mating disruption (MD) is an alternative IPM strategy that has been used for decades in the tree fruit industry for management of the key lepidopteran "worm" pests. The tactic has not been widely used in vegetable systems. MD prevents male moths from finding females and so reduces and delays the establishment of larval infestations in commercial fields. MD technology can be delivered through various mechanisms, including dispensers and sprays. With the sex pheromone of DBM synthesized in high quantities and commercially available in various forms, we are able to employ this tactic.

In 2022, we conducted a large-scale (on-farm) mating disruption trial in Carroll County, VA, where >500 acres of commercial cabbage are grown mostly in spatially-isolated relatively small <10 acres fields. Six fields received Trece Inc. high-dose DBM MD dispensers (four per acre installed on stakes). Another six fields served as an untreated control. The growers applied their normal insecticide program in all fields. Three Pherocon 1C sticky traps were installed in the middles of each field and were baited with a rubber septum containing DBM pheromone (Fig. 2). DBM moth catch on a trap represents the possibility of a successful mating event in the field, and thus can be used to show efficacy of the strategy (no moths = no successful DBM mating in the field). Traps were checked weekly over the season and showed very encouraging results (Fig. 3).

Fig. 2. Pherocon 1C sticky traps from control fields covered in DBM moths versus mating disruption fields with no moths caught.

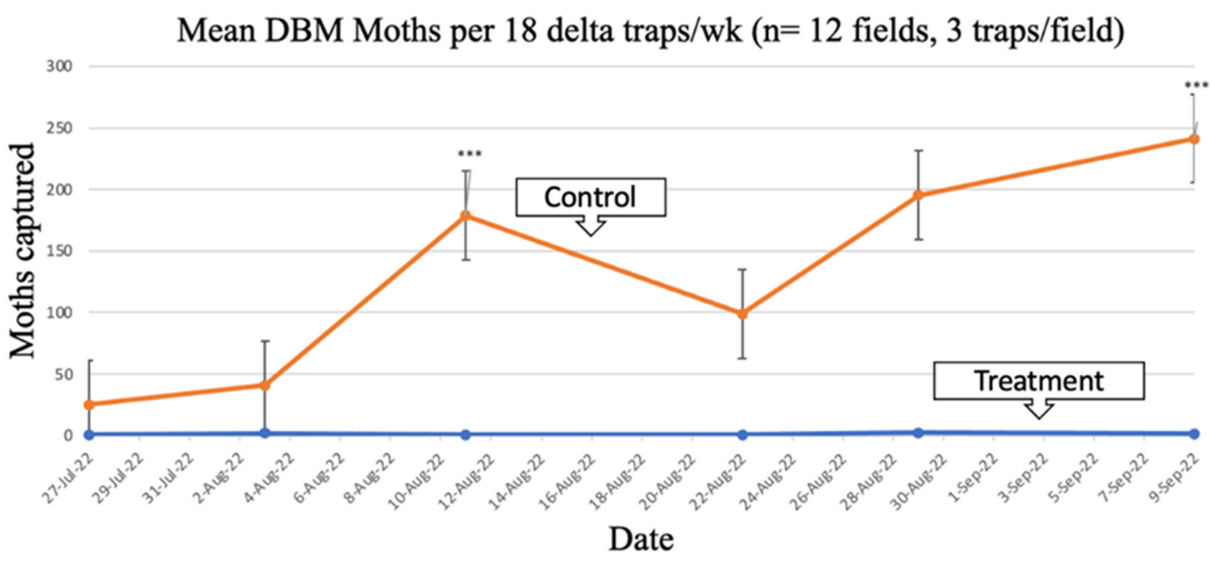
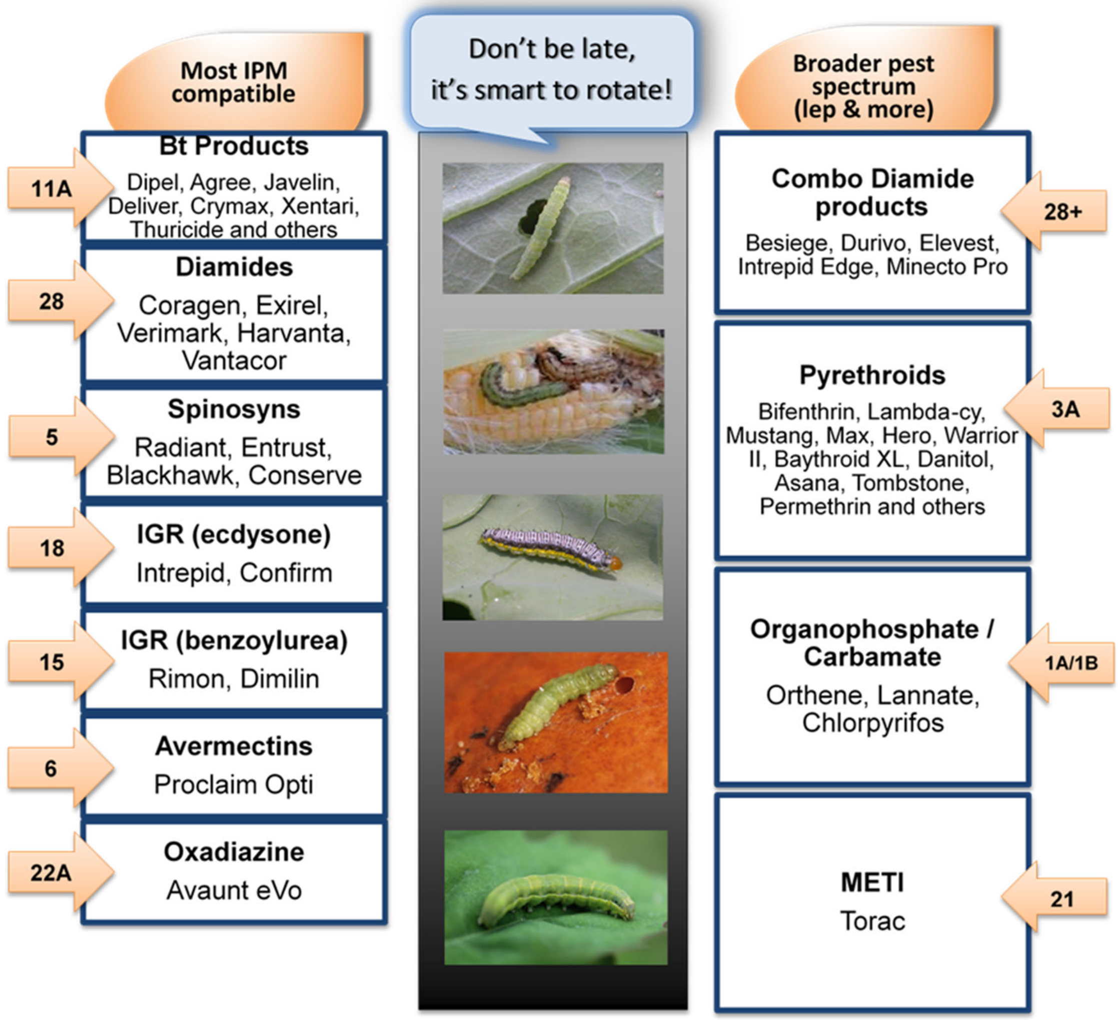


Fig. 3. Trap catch of DBM moths within commercial cabbage fields under mating disruption (blue line) versus no mating disruption dispensers deployed (orange line) in Carroll Co., VA in 2022.

The technology has shown promise for reducing reliance on conventional insecticides, however additional research is needed to optimize the scale and delivery methods for broad grower adoption.

Like mating disruption, biorational (or IPM-compatible) insecticides can reduce DBM pest populations without significantly impacting beneficial arthropods. A wide range of insecticides from different mode of actions are registered for use on brassica crops and many have shown to be effective on DBM and other lepidopteran pests. We compiled insecticides into a chart showing IPM-compatible options (Fig. 4. left side) versus broad-spectrum options (Fig. 4 right side), which would provide control of non-lepidopteran pests as well.

Fig. 4. Lepidopteran Insecticide Menu for Vegetable Growers (Grouped by insecticide MOA class) – Adapted from Kuhar and Doughty 2020. Virginia Coop. Ext. Publ. ENTO-395NP



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 including DBM. The effectiveness of these insecticides against non-lepidopteran pests is less understood. In 2022, 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 (4 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 DAT2)**	**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).

STRATEGIES FOR MANAGING TROUBLESOME WEEDS IN COLE CROPS

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Cole crops are a very diverse group of vegetable crops that includes in our region cabbage, broccoli, kale, cauliflower, Brussels sprouts, kohlrabi, and collards. These crops will vary in their growth habits and characteristics which will influence our options for managing weeds. Additionally, herbicide sensitivity may significantly differ between species, and even between varieties within a species. The most important period during which weed competition may affect crop development and yield is around crop seed germination or transplanting, and in the few weeks that follow. During this period, the rapid growth of weeds can deprive crop seedlings from absorbing water, nutrients, and light. Therefore, maintaining a weed-free environment over the course of the three to five weeks that follow crop seed germination or transplanting is crucial for maintaining your crop yield potential. Later, the development of some cole crops (kale, cabbage, cauliflower…) will provide sufficient shading of the ground for reducing the need for weed management.

Scouting for Weeds

Weeds must be targeted at the seedling stage since controlling fully developed weeds can be extremely difficult because of their size that prevent effective herbicide distribution on the plant or because of their ability to regrow following mechanical or chemical control. Scouting for detecting weed seedlings shortly after their emergence is a critical component of any successful weed management program. The goal of weed scouting is to get a representative idea of the weed populations throughout the whole field. For a 100-acre field, make 5-10 stops that are well spread out through the field. At each stop, walk 10 paces (or 30 feet) and record the weed species that are present as well as their lifecycle (summer annual, winter annual, perennial), growth stage or height, and the severity of the infestation based on number of plants (low, medium, high). An efficient scouting program should also provide information on crop phenology as this is very important with regards to chemical weed control since most postemergence herbicides are only effective when weed seedlings do not exceed a specific size. The use of farm maps for weed scouting will provide data that can be used to define the control strategy but also assess its efficiency at controlling weeds over time.

Weed Identification

Accurate weed ID is important for effective management because herbicide recommendations vary according to species, as do some mechanical, cultural, and biological strategies. Some species can look like other species from afar but may have drastically different management requirements. They should be examined closely to determine herbicide programs. Guides such as *Weeds of the Northeast* or weed identification websites can be helpful to accurately determine weed species and become familiar with their biology and ecology. A list of weed identification websites is available on the Weed Science Society of America website (https://wssa.net/wssa/weed/weed-identification/weed-id-pages/). An updated edition of the Weeds of the Northeast guide will be released in March 2023 and cab be preordered from the Cornell University website (https://www.cornellpress.cornell.edu/book/9781501755729/weeds-of-the-northeast/#bookTabs=1).

Additionally, cellphone apps such as iNaturalist (https://www.inaturalist.org) can really help identifying weeds in the field if good quality and multiples weed pictures are uploaded to the app or the website.

Weed Management prior to Cole Crops Planting

- To prevent the buildup of weed seed in the soil, cultivate weeds before they set seed in rotation crops. After harvest of the rotation crop, clean cultivate the field, plant a green manure crop, or use an herbicide to prevent weed infestations. To control yellow nutsedge foliage and suppress nutlet formation, spray with a labeled glyphosate product after nutsedge flowers appear, but before foliage dies. Expect only partial control of yellow nutsedge the first year after initiating the program Effective yellow nutsedge control can be achieved by repeating the application for several consecutive years. A late summer or fall application of glyphosate mixed with dicamba or 2,4-D to healthy weed foliage can help suppress broadleaf perennial weeds such as field bindweed, Canada thistle, horsenettle or bitter nightshade.
- Just before planting cole crops, superficial soil cultivation followed by irrigation of the field will stimulate weed seed germination. Cultivation should be as shallow as possible in order not to bring up dormant weed seed from deeper soil layers. Weed seedlings can then be controlled with cultivation or the use of a nonselective herbicide such as Gramoxone (paraquat) or Roundup (glyphosate) to destroy them. Carrying out this operation as close to planting time as possible ensures that soil temperature and climatic conditions are similar to those that will occur during the crop germination/transplanting period, thus maximizing the number of weeds controlled.
- Transplant cole crops into uniform beds utilizing a precision planting system that will promote a uniform crop and allow cultivation close to the seed line. This reduces the need for hand hoeing and lowers weed control costs.
- Various herbicides are labeled on cole crops for soil applications prior to weed emergence and crop planting. However, some herbicides may only be labeled for specific cole crops. For example, GoalTender (oxyfluorfen) is a very effective soil-applied herbicide that is labeled for use on broccoli, cabbage and cauliflower, but **NOT** labeled on Brussels sprouts, collards, kale and kohlrabi. Dual Magnum (*S*-metolachlor) is very effective at controlling grassy weeds prior their emergence but is only available through a New Jersey 24(c) Special Local Need label for use on transplanted or direct-seeded cabbage. There are also restrictions on soil-applied preemergence herbicides based on the production system. For example, GoalTender (oxyfluorfen) can ONLY be used on transplanted broccoli, cabbage,

and cauliflower. Use of this herbicide on direct-seeded broccoli, cabbage, and cauliflower would kill germinating seedlings or cause unacceptable crop injury. On the opposite, Treflan (trifluralin) is labeled both for direct-seeded and transplanted broccoli, Brussels sprouts, cabbage, cauliflower, collards, and kale. Please, **always** refer to the most recent version of the herbicide label, or to the Mid-Atlantic Commercial Vegetable Production Recommendations (https://njaes.rutgers.edu/pubs/publication.php?pid=e001) for specific restrictions before deciding to apply an herbicide.

Weed Management after Crop Emergence

- Close cultivation is only possible before runners (vines) are produced. Hand hoeing is often used to supplement machine cultivation and thin the crop to the required density. Late-season hand hoeing can help reduce weed seed but may cause some yield loss.
- Gramoxone (paraquat) can be used as a shielded application in row middles to control emerged weed seedlings after planting. As a contact herbicide that will not be translocated within the plant, Gramoxone should be mixed with a nonionic surfactant at 0.25% v/v to maximize the spreading of the spray solution on the weed leaf surface. For efficient weed control, applications should be made on small well seedlings. Shields or hoods should always be used to prevent spray contact with the crop and applications should be made at a low spray pressure (maximum of 30 psi) to reduce small droplets that are prone to drift. Aim (carfentrazone) can be applied as a hooded spray to control small broadleaf weeds between crop rows. Avoid contacting cucurbits, because carfentrazone may cause injury.
- Poast (sethoxydim) and Select Max (clethodim) can be used to control seedlings of some annual and perennial grasses (graminicides). The effectiveness of these materials, however, is reduced when grasses are under moisture stress. Later growth stages of annual grasses are more difficult to control. Follow the label instructions regarding the use of adjuvants as well as grass growth stage to maximize effectiveness of the graminicides. Sethoxydim will not control annual bluegrass and it varies in its ability to control particular grass species. For effective control of perennial grasses (quackgrass), a minimum of two applications will be required.
- During cooler seasons or for crops that have a long growing season, a layby soil-applied herbicide can be beneficial to control late emerging grasses and annual broadleaf weeds. They are applied as a directed spray to the soil surface when the crop has four to five leaves, taking care not to contact the crop foliage. None of these herbicides will control emerged weeds; they are only effective on germinating seed. Their main benefit is to keep the weed populations low to facilitate harvest. Herbicide carryover may occur under certain conditions, creating a plant back problem. Consult the herbicide label before application.

WHAT HAPPENED WITH CORN EARWORM IN 2022?

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The Vegetable IPM Program has been tracking CEW populations for over 20 years using both blacklights, initially and then, in conjunction with pheromone traps. The population trend has generally been in decline (Fig 1) for at least the past 10 years. However, the population in 2022 tripled over the 2021 counts in southern NJ as measured by the pheromone trap catches (Fig.2)

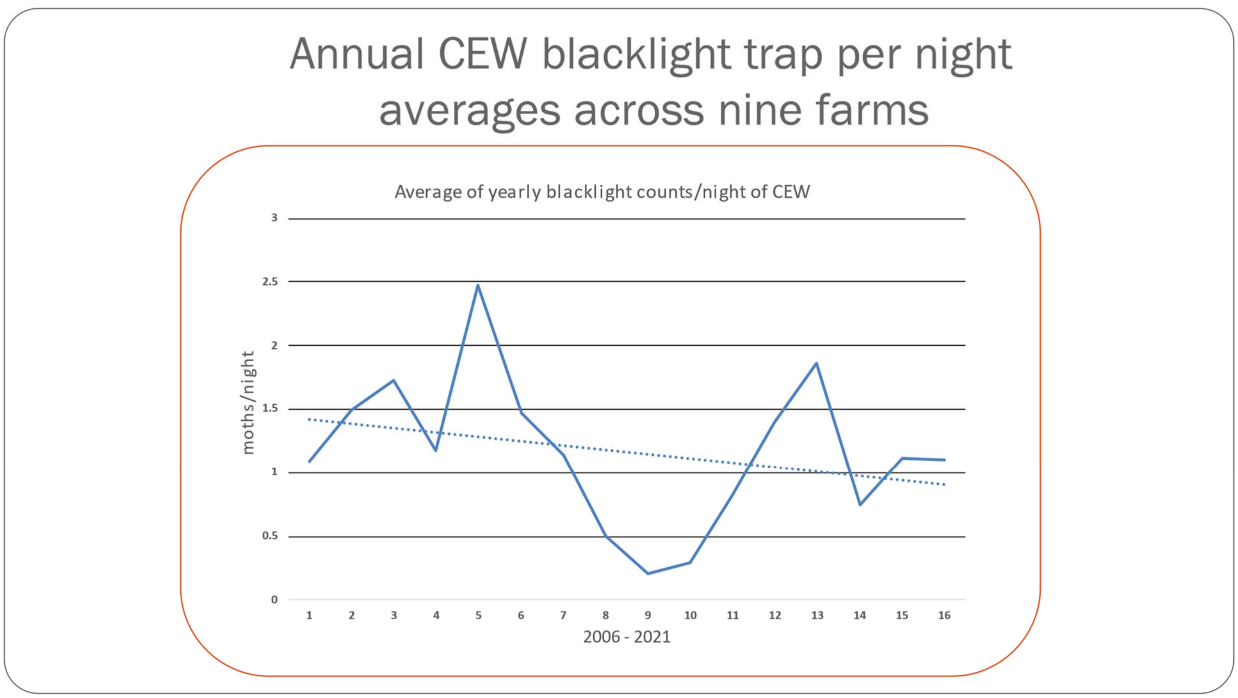

Figure 1. Population trend of CEW from nine farms across northern, central and southern New Jersey based upon blacklight traps

Figure 2. Comparison of the pheromone catch between 2021 and 2022. n= # of traps. There are three clusters of farms in South Jersey corresponding to Cape May, northern and southern areas.

2022 pheromone cew moth counts for August

Cape May (n = 2)	6668
Northern (n = 9)	14651
Southern (n= 5)	12867
	Total 34,186

2021 pheromone cew moth counts for August

Cape May (n = 2)	1371
Northern (n = 8)	5213
Southern (n= 5)	5259
	Total 11,843

The difference between years is exceptional, but what has caused this disparity is unknown, at present. Usually, weather fronts that have moved into southern NJ from the southeast brings in CEW moths. In 2022, especially, moth counts often rose dramatically when weather fronts moved in from the west. Pheromone trap counts in central and northern NJ had slightly higher to no difference in typical trap catches. Not all trap sites experienced higher than normal counts with several that maintained somewhat low seasonal numbers.

The extremes in trap catches further exacerbated recommendations for spray schedules. A new grant proposal for the mid-Atlantic region is currently being developed and once funded, we may be able to better understand the population dynamics of CEW and develop improved thresholds for managing this pest.

Session 7

High Tunnels

Session *Chair:*
A J Both

High Tunnel Construction

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High tunnels are greenhouse-like structures designed to be relatively inexpensive and as a result typically have minimal control features. The resulting low-tech structures are usually covered with a single layer of greenhouse film and use roll-up sides as ventilation openings in the case of free-standing tunnels, or end-wall openings and push-back roof covers in the case of gutter-connected tunnels.
While it is possible to construct high-tunnels onsite with available farm labor and using readily available construction materials, most growers opt to purchase a pre-designed kit that they then put together onsite. Several manufacturers offer such kits and these kits are typically made available in different dimensions and with different features (e.g., construction materials, end wall designs, vent designs). Certain design features are region specific. For example, for locations with a lot of snow, a gothic arch roof design more readily facilitates snow shedding. And for locations with high wind conditions, high tunnel designs are needed that prevent wind damage. For tunnels that are used during the winter months, minimizing unintended air movement through small cracks and openings will improve temperature control.
This presentation will address issues such as siting, orientation, installation, ventilation, and end wall design. Several alternatives will be presented and discussed. High tunnels have proven to increase yields of certain crops compared to field production, especially during seasons with adverse weather conditions. But high tunnels increase the cost of crop production and should therefore be designed and operated as efficiently as possible.

DESIGN AND MANAGEMENT OF HIGH TUNNEL VENTILATION

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Freestanding high tunnels are cost-effective, plastic film-covered growing structures that use very little to no modern environmental control technology. Natural ventilation is used to control temperature and humidity. This presentation covers a research project that investigated design and management decisions that impact the high tunnel environment and ventilation, including vent design, high tunnel orientation, plant canopy height, shoulder-season management, and high tunnel row spacing. Additionally, practical recommendations will be discussed related to how the findings of this research can be implemented by growers.

The main tool used for this research was computational fluid dynamics (CFD) simulations because they can accurately and quickly describe the airflow within a complex system, while allowing for an iterative design process. Field experiments were conducted at the Pennsylvania State University High Tunnel Research and Education Facility (Rock Springs, PA) in order to collect environmental data within and immediately outside of a reference high tunnel. This data was used to validate a CFD model made using commercially available software (ANSYS Fluent), which incorporated the physical processes of energy transfer (convection, conduction, and radiation), turbulence, plant canopy induced drag, plant evapotranspiration, and water vapor transport. The model had a mean absolute error of 0.997 °C (n= 144), showing good agreement between experimental and simulated results since this error is less than the measurement error of the temperature sensors used. Permutations to this base model were made to investigate the research questions posed. These included separate simulations of five roof vent designs, three tunnel orientations, three plant canopy heights, four distinct sets of weather conditions representing the colder periods of the year, and five row spacings for two different sized tunnels (research size and commercial size).

EXPERIENCES WITH MOVEABLE HIGH TUNNELS

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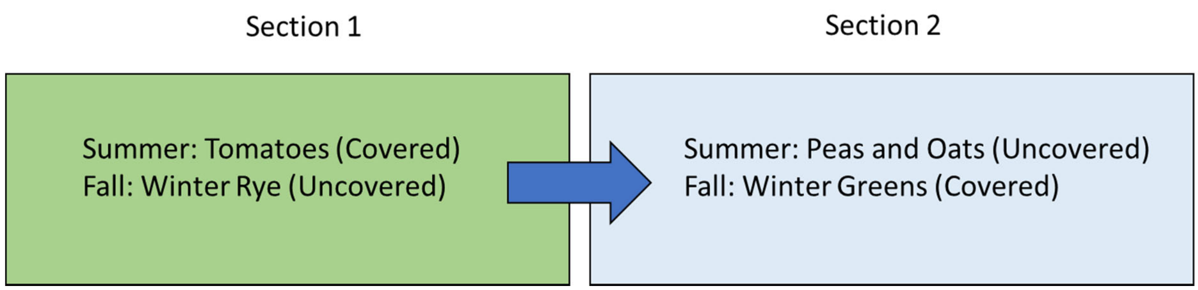
High tunnels provide many advantages to growers in various commodity groups. The protective covering can offer season extension giving the farmer harvestable crops both earlier in the spring and summer and later into the fall and winter. Reduced rainfall and soil splashing also reduces disease problems leading to the production of higher quality and higher value crops. Moveable high tunnels have all the benefits of stationary tunnels, in addition to the fact that they can be moved along a rail or track from one crop to another throughout the growing season. This maximizes the timing and efficiency of field operations, improves crop rotation and diversity, and reduces salt build up in the soil by allowing rainwater to flush the soil after the tunnel is moved to a different location.



A simple example of using a moveable high tunnel to maximize productivity and soil health involves dividing a field into two sections that can each be covered by the tunnel. In the summer, the high tunnel is in position 1, covering a crop of tomatoes. During this time, the other section is cover cropped to build soil fertility. In late summer, section 2 is planted to cold-hardy winter greens while the tomatoes remain covered. When the tomato crop is finished in the fall, the tunnel is moved over top of the winter greens to provide frost protection into the winter months. Section 1 can then be cover cropped with winter rye to protect the soil through the winter. Limitless creative and complex rotations can be developed using additional field sections to fit any farming operation.

<u>Benefits of Moveable High Tunnels</u>

- Low-cost infrastructure
- Season extension
- Better crop rotation
- Reduced insect and disease issues
- Reduced salt build-up in the soil
- Higher quality crops

Two moveable high tunnels were built at the Rutgers Specialty Crop Research and Extension Center in Cream Ridge, NJ. The tunnels were built using a hoop bender and common materials that can be purchased from a hardware or farm supply store. The construction process was recorded, and an instructional video and written document will be available for growers who want to build their own high tunnels. The tunnels can be made to any length, with a 24-foot long tunnel costing approximately $1300 in materials, making them accessible to new farmers and established operations alike. This infrastructure is in place for a variety of research and demonstration projects going forward that can be designed to meet the evolving needs and interests of the farming community. Thus far, trials have been successfully conducted on growing African marigolds, ginger, turmeric, and winter greens in the moveable tunnels at the Extension Center.

Examples of crops that can be grown in the moveable high tunnel include:

- Tomatoes
- Peppers
- Eggplants
- Basil
- Winter Greens
- Sunflowers
- African Marigolds
- Tulips and Spring Bulbs
- Ginger
- Strawberries
- Brambles
- Cut Flowers

Additional Resources:

High Tunnels in New Jersey: https://sustainable-farming.rutgers.edu/high-tunnels-in-new-jersey/

Movable High Tunnels: Opportunities and Challenges for Growers: https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/MovableHighTunnels-CCD-SP-15.pdf

High Tunnel Winter Lettuce: https://njaes.rutgers.edu/ultra-niche-crops/high-tunnel-winter-lettuce/

High Tunnel Control with Sensors

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By definition, high tunnels are low input structures used to extend the growing season, or to allow year-round production (using cold-hardy crops during the winter months). The choice for a low input system may be necessary when there are no energy sources available (for heating and electric power), or it can be a deliberate choice due to the desire to keep the production costs low. However, the absence of energy sources results in additional labor needed for maintaining optimal growing conditions. As a result, during the spring and fall seasons frequent adjustments of the vent openings are needed to control the indoor temperature and humidity levels. In addition, if a crop is grown during the winter months, additional measure may be needed to protect the crop from cold temperatures (e.g., covering the crop with a protective insulating layer during the nighttime).

When labor is available, the extra time needed to maintain optimal conditions in a high tunnel may not be a major issue. In fact, it may be helpful to have somebody check on the structure and the crop regularly. However, when labor is scarce, it may be helpful to automate some of the necessary activities (e.g., adjusting the ventilation openings). But in that case electric power is needed to activate a pipe motor used to adjust the vent opening. In addition, a sensor system is needed that is able to keep track of the high tunnel conditions and determine when adjustments are needed based on the control set points. Clearly, using sensors and a control system adds complexity and costs to high tunnel production, but the resulting labor savings might make this approach worthwhile considering.

This presentation will focus on the challenges and opportunities associated with automated control of the high tunnel environment. Different approaches and hardware will be discussed with an emphasis on temperature and humidity control. Especially humidity control can be challenging because the removal of excess moisture is typically accomplished through ventilation, which may not be desirable when the outdoor temperatures are low. In that case, the benefits of lower humidity conditions have to be weighed against the drawbacks of lower high tunnel temperatures. Obviously, these decisions are crop specific depending on the optimum growing conditions for the various plant species produced in high tunnels.

Session 8

Soil Health

Session Chair:
Michelle Infante-Casella

MAKING YOUR OWN FERTILIZER: ON-FARM COMPOSTING

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Compost is one of the best ways to enhance soil organic matter content, which helps to build a fertile soil structure. Such a soil structure makes better use of water and nutrients. Populations of microorganisms that make soil come alive with productivity and enable plants to battle diseases and pests thrive in such an environment. Because compost has already decomposed, the impacts of compost are much more long-lasting than crop residues and green or animal manures that rapidly degrade when added to the soil. Composting also gives farmers a way to recycle manures and plant residues that otherwise might present some environmental problems. In many instances, a good composting program also allows farmers to save money by eliminating or trimming the need for farm fertilizers and other expensive inputs.

Composting is not merely a matter of heaping up organic materials and allowing them to rot. Rather, it's a biological process that requires careful monitoring of air and moisture levels in compost piles or windrows to produce specific temperature ranges that promote the growth of beneficial microorganisms. These tiny hosts can turn farm manure, plant residues, and other organic materials into a valuable resource — finished compost.

HOW THE COMPOSTING PROCESS WORKS

Compost is the material that results when recycled plant wastes, biosolids (solid materials like manure), fish, and other organic materials decompose aerobically — through the action of microorganisms that live in the presence of air. Depending on the organic matter being composted, it may take up to six months to produce a mature batch of compost. There are ways to speed up the process though, such as grinding woody materials so they decompose faster. After the materials decompose, many compost mixtures require a curing time that lasts up to 30 days. The final product should be dark brown to black in color, sweet smelling or at least neutral in aroma, soil-like in texture, and with particles reduced to ½-inch or less in diameter. None of the original feedstocks, the materials used to make the compost, should be recognizable.

What distinguishes composting from natural rotting or decomposition is human involvement. A farmer arranges the materials to be composted into appropriate piles or windrows and then carefully monitors the amounts of oxygen and moisture that are introduced to those materials to produce optimum temperatures averaging from 120 to 140 degrees Fahrenheit (°F).

Most who make compost properly use a special thermometer with a 2- to 3- foot probe to take regular temperature readings of the composting materials. If temperatures fall below or climb above the optimum ranges due to various reasons, microorganisms begin to die off. The farmer then supplies more moisture or oxygen by wetting and turning the piles or sending streams of air through vented pipes into the composting materials to help regulate temperature and the compost pile environment.

Mesophilic and Thermophilic Stages

If the proper conditions exist, the pile begins to heat up almost right away. This first phase of composting, lasting one to two days, is called the mesophilic stage. In this stage, strains of microorganisms (the species that are most active at temperatures of 90° to 110°F) begin to break down the readily degradable compounds in the pile. As they rapidly consume sugars, fats, starches, and proteins, heat is given off, and the temperature of the substrate (materials base) rises. The pile becomes active, and a series of processes are set in motion.

The next phase in the composting process is the thermophilic stage, which can last for several weeks. As active composting takes place, temperatures in the center of the pile climb to about 120° to 150°F. At these temperatures, heat-loving (thermophilic) bacteria vigorously degrade the organic material. Temperatures will remain in this range as long as decomposable materials are available and oxygen is adequate for microbial activity. Many important processes take place during the thermophilic stage. As the organic matter degrades, its particle size is reduced. Pathogens are destroyed as the heat in the pile climbs above a critical temperature of 131°F. Fly larvae and most weed seeds are destroyed at temperatures above 145°F.

Temperature Is Critical

Decreasing temperatures in the composting pile indicate that more oxygen or moisture is needed. The pile may need to be turned to reintroduce oxygen for renewed microbial activity. In this operation, the pile or windrow is re-mixed by hand, with a frontend loader, or with other specialized equipment. Alternatively, perforated pipe can be placed under the pile during construction so oxygen can be delivered from blowers and fans into the pipe. Turning the pile also insures that materials are moved from its outer layers, where temperatures may be lower than 120°F, to its inner layers, where they will be subject to thermophilic temperatures. Several turnings also can ensure destruction of most pathogens, weed seeds, and insect larvae. It is also possible for temperatures in the pile to become too hot. When temperatures reach the 150°F to 160°F range, thermophilic organisms begin to die and composting slows.

Spontaneous combustion can occur in compost piles that become too hot and dry. If the moisture content falls below 40 percent, the pile may become too dry for microbial activity and the pile may require water to be added to keep microbes alive. The Moisture Squeeze Test A general rule of thumb is that the pile is too wet if water can be squeezed out of a handful of compost and too dry if the handful does not feel moist to the touch.

There's also a danger in making the pile too wet. When moisture content exceeds 65 to 70 percent, much of the pore space, the space between particles in the pile, will contain water rather than oxygen. Oxygen will then quickly become limited, and microbial activity will decrease, as reflected by the decreasing temperature. Without sufficient oxygen, the pile will become anaerobic. Anaerobes, an entirely different set of microorganisms that function effectively without oxygen, will assume primary responsibility for decomposition. Unfortunately, anaerobes break down materials at a much slower rate than aerobic microorganisms. Slow decomposition produces many undesirable byproducts, among them noxious odors that have been compared to the rotten-egg smell of hydrogen sulfide gas. It also creates organic acids that can inhibit plant growth.

When active composting is finally completed, temperatures in the pile or windrow will gradually fall to about 100°F. Turning the compost or applying moisture will no longer cause temperatures to rise. The volume of the original materials will also be reduced by 25 to 50 percent. Decomposition continues beyond this point, but at a much slower rate, and little heat is generated. When the compost pile temperature falls to that of ambient air, the compost is ready for curing. The curing stage, in which compost is allowed to rest undisturbed, takes about 30 days. Curing helps to ensure that the compost is fully matured, that any remaining weed seed and pathogens are destroyed, and that beneficial microorganisms re-colonize the compost.

Composting Methods

• Passive Pile Method

This method has mixed or often poor results because organic materials are placed in a pile and left alone to decompose over an extended period of time. This method is not approved for certified organic farms. Manure is often composted with this method. Farmers who use this method may or may not use a compost recipe, and they usually make no attempt to adjust moisture content or the carbon to nitrogen (C:N) ratio. The piles are not aerated, and their temperatures, which are so critical to proper composting, are not monitored. Passive compost piles often turn anaerobic, when organisms that do not require oxygen take control of the decomposition process. Foul odors (and complaints from neighbors) often accompany passive compost piles, which decompose slowly at best. BEWARE Neighbors down-wind may start complaining about odors. Be sensitive to the concerns of neighbors about the composting operations on your farm. Noxious odors from improper processing (typically insufficient oxygen) and stockpiled feedstock materials, dust, noise from equipment, and fly or mosquito problems may strain neighborly relations.

• Windrow Method

This method is approved for certified organic production. In the windrow method, a mixture of feedstock materials is placed in a long, narrow pile. The pile is turned or mixed on a regular basis to provide oxygen throughout the pile. Turning the pile also helps to rebuild the pore space in the pile that is lost by settling and reductions in particle size. It is also important periodically to exchange outer layers of the pile, which will have cooler temperatures, with the warmer inner layers. Maintaining the correct temperature in a compost pile is essential for fostering the microorganisms that decompose feedstocks and for killing off pathogenic organisms and weed seeds.

Farmers should size windrows in relation to the materials that will be composted and the turning equipment that will be used. For dense materials that allow less passive air movement in and out of the pile, piles might only be 3 feet high and 10 feet wide. For more porous materials like leaves, piles can be as much as 12 feet tall and 20 feet wide. One should guard against making piles too large. Depending on the nature of the ingredients, a pile with a wide cross-section can have anaerobic pockets in the interior.

Windrows are normally turned with frontend loaders or compost turning machines. Front-end loaders allow for tall piles, whereas turning machines normally produce low, wide piles. How often a windrow pile is turned is determined by many factors, including the season and farm microclimate, the temperature, and moisture content. Microbial decomposition, which is related to the age of the pile, decreases over time as organic materials in a windrow are fully composted.

Windrow temperature is critical and is the most commonly used turning indicator. As mentioned above, the microorganisms that drive the composting process thrive best when composting piles and windrows are kept between 120 to 140 °F. Generally, a pile should be turned when its interior temperature falls below 120°F. Thermometers with a special 2- to 3-foot stem are used to measure temperatures at 50-foot intervals along the windrow.

Maintaining the proper temperature is also critical for meeting what are called PFRP requirements. PFRP stands for processes to further reduce pathogens. These requirements stipulate the composting processes that must be used to maintain reduced levels of organisms that can be harmful to humans, referred to as human pathogenic organisms. PFRP requirements also apply to vectors, the carriers of those pathogens.

Some USDA Target Ranges for Compost Piles
• temperature of 120 to 140°F
• moisture content of 50 to 60 percent.
• pH of 6.5 to 8.5
• bulk density of less than 1,100 pounds per cubic yard (40 lb. per cubic foot)

As composting proceeds, the volume of each windrow will decrease. If a pile becomes too small to maintain the correct temperature range, it should be combined with another pile.

•Aerated Static Pile Method

This method is approved for certified organic production. In the aerated static pile method, compost is not turned. Instead, air is supplied for microbial activity through perforated pipes that are placed along the bottom of the windrow or pile. Fans or blowers either blow air into the pile or suck air out of the pile. An insulating layer of finished compost or a bulking agent, such as wood chips or straw, normally covers the pile to retain heat. This layer also helps maintain the desired moisture content, discourages egg-laying by flies, and serves as a biofilter to scrub away noxious odors that may be generated by composting.

With this method, feedstocks are piled on top of a 6-inch base of a porous material, such as wood chips, chopped straw, or some other bulking agent. The perforated pipe is placed in this base material. Piles are 5 to 8 feet high, depending on feedstocks, climate, and equipment. Fans deliver air to the perforated pipe, and the porous base serves to distribute the air throughout the pile. Conversely, suction in the perforated pipe draws air through the pile.

When constructing an aerated pile, it is important to extend the walls of the pile beyond the width of the 6-inch porous base. Otherwise, air will flow solely through the base itself and not through the pile. A good rule of thumb is that the width of the porous base should be only 1/4 to 1/3 of the width of the pile of feedstock materials. The base should stop short of the end of the pile by a distance approximately equal to the pile height. The length of the pile should normally be less than 70 to 90 feet. Composting is faster with the aerated static pile method, typically taking from three to five weeks. For a detailed description of the engineering, construction, and management of aerated static systems, refer to the On-Farm Composting Handbook, which is cited in the recommended reading list at the end of this publication.

Compost Recipes

Many farmers base the construction of a pile or windrow on their personal judgment of moisture, texture, and feedstock materials. From past experience, they make a rough calculation of a mixture's carbon to nitrogen (C:N) ratio. However, these trial and-error methods may not always produce the best results. More often, developing an appropriate compost recipe based on some definite calculations is a better way to consistently obtain a high quality, finished product in a timely manner. Proper proportions of feedstock ingredients can be calculated using procedures that are described in the On-Farm Composting Handbook (see link on last page). Calculations in the handbook predict the moisture content and C:N ratio of a mixture of feedstocks based on the characteristics of the individual raw materials.

First, the moisture content of each feedstock must be determined. Appropriate proportions of each feedstock are based on moisture content. Then, if necessary, the proportions are adjusted to bring the C:N ratio in line without excessively changing moisture content. Compost Recipe Software Computer software is available that simplifies compost recipe calculations when three or more ingredients are used. The Cornell University Web site provides user-friendly spreadsheets at www.cfe.cornell.edu/compost/science.html (Cornell University, 1995).

Identifying Feedstock Sources

The first step in producing high quality compost for sustainable or certified organic production is to identify the source of all feedstocks used to make the compost. Examples of National Organic Program approved feedstocks (materials that can be composted) include, animal bedding, crop residues, yard wastes, fish and food processing wastes and byproducts, seaweed, many byproducts of the plant industry, and manures.

Meeting Carbon:Nitrogen (C:N) Ratios

When composting mixed plant and animal feedstocks, organic producers must meet what is called the C:N 25:1 to 40.1 ratio. This ratio refers to the carbon and nitrogen content of feedstocks. It has been developed to help farmers produce high quality compost that is fully mature, so that any pathogens and their vectors (such as fly larvae), weed seeds, and other contaminants have been rendered harmless. The ratio allows for very diverse combinations of feedstock materials. It is also meant to help producers establish conditions that favor the time and temperature criteria required by the Compost Practice Standards. C:N ratios that are outside this range generally result in immature, incompletely digested compost. Farmers should note that there are no specific regulations for composting when feedstocks are made up of only plant materials.

Determining C:N Ratios

How do producers determine the carbon and nitrogen content and ratios of various feedstocks? For the most part, they consult available sources that estimate these values and ratios for approved feedstocks. Values of the carbon and nitrogen content in common manures and plant materials are generally available. Other feedstocks may be tested once and, given consistent quality, assumed to approximate that value for later use. Fortunately, the range of C:N ratios permitted by the National Organic Rule allows for considerable flexibility in constructing a pile that composts properly.

Table 1. Characteristics of Compost Feedstocks [1]

Material	% N (dry wt)[2,3]	C:N (wt/wt)[4]	Moisture % (wet wt)	Bulk Density (lb/cu yd, wet wt)
Plant Residues				
Apple filter cake	1.2	13	60	1,197
Apple pomace	1.1	48	88	1,559
Corn stalks	0.6 - 0.8	60-73	12	32
Cottonseed meal	7.7	7	-	-
Cull potatoes	-	18	78	1,540
Fruit wastes	0.9-2.6	20-49	62-88	-
Potato processing sludge	-	28	75	1,570
Rice hulls	0.3	121	14	202
Soybean meal	7.4	4-6	-	-
Vegetable produce	2.7		87	1,585
Animal Residues				
Blood wastes	13-14	3-3.5	-	
Crab wastes	6.1	5	47	240
Fish wastes	10.6	4	76	-
Poultry carcasses	2.4	5	65	-
Shrimp wastes	9.5	3	78	-
Manures				
Broiler litter	1.6-3.9	12-15	22-46	756-1,026
Beef	1.5-4.2	11-30	67-87	1,323-1,674
Dairy	3.7	13	83	775
Horse	1.4-2.3	22-50	59-79	1,215-1,620
Layers	4.0-10.0	3-10	62-75	1,377-1,620

Table 1. (continued)

Material	% N (dry wt)[2,3]	C:N (wt/wt)[4]	Moisture % (wet wt)	Bulk Density (lb/cu yd, wet wt)
Sheep	1.3-3.9	13-20	60-75	-
Swine	1.9-4.3	9-19	65-91	918
Turkey litter	2.6	16	26	783
Municipal Wastes				
Food waste	1.9-2.9	14-16	69	-
Paper	0.2-0.25	127-178	18-20	-
Refuse (mixed)	0.6-1.3	34-80	-	-
Sludge	2.0-6.9	5-16	72-84	1,075-1,750
Straw, Hay, Silage				
Corn silage	1.2-1.4	38-43	65-68	-
Hay (legume)	1.8-3.6	15-19	-	-
Hay (non-legume)	0.7-2.5	32	-	-
Straw (wheat)	0.3-0.5	100-150	-	-
Wood and Paper				
Bark (hardwood)	0.1-0.4	116-436	59	471
Bark (softwood)	0.04-0.39	131-1,285	40-50	225-370
Corrugated cardboard	0.1	563	-	259
Newsprint	0.06-0.14	398-852	-	195-242
Sawdust	0.06-0.8	200-750	-	350-450
Wood chips/shavings (hardwood)	0.06-0.11	451-819	-	445-620
Wood chips/shavings (softwood)	0.04-0.23	212-1,313	-	445-620
Yard Wastes				
Grass clippings	2.0-6.0	9-25	82	300-400
Leaves	0.5-1.3	40-80	38	100-300
Seaweed	1.2-3.0	5-27	53	-
Shrub trimmings	1	53	15	429
Tree trimmings	3.1	16	70	1,300

1. Source: *On-Farm Composting Handbook*, NRAES 54
2. Where a range is not given, data indicate an average value.
3. A dash indicates that information is not available.
4. All ratios are expressed relative to 1; e.g., the C:N of apple filter cake is 13:1

Calculating Nitrogen Content

Determining an accurate nitrogen (N) content for a particular compost when trying to calculate application rates for a crop can be tricky. By the time compost has reached maturity, it has undergone extensive microbial degradation and stabilization. It will take longer than one cropping year to further mineralize (break down) the remaining recalcitrant organic N in the compost. Therefore, if application rates are based on the total amount of nitrogen in the compost (which includes this recalcitrant organic N), crops may experience nitrogen deficiency and yields may be poor. So, we must calculate the agronomic rate of compost application by the compost's plant-available N (PAN), which is a fraction of the its total N.

Another consideration to keep in mind is that soil temperature and moisture influence the availability to plants of recalcitrant organic nitrogen. Cool or wet weather, or a combination of these, slows microbial activity and thus inhibits mineralization processes. Consequently, the organic nitrogen in compost may not become mineralized by the time crop demand is greatest. For example, compost may not be able to supply nutrients at crop emergence in a wet, cool spring.

N Content: Compost Versus Manures

The concentration of available N in finished compost is generally lower than that in manures. As a consequence, application rates are generally higher, allowing for greater organic matter additions to soil. Thus, use of compost as a nutrient source instead of manure alone provides a greater opportunity to improve the soil's physical properties.

Composts with high carbon to nitrogen (C:N) ratios (20:1 and above) are relatively more resistant to further degradation. So, nitrogen is slower to mineralize and to become available for plant use in these composts. The C:N ratio of mature compost is commonly in the range of 8 to 14:1. Predicting how much and when nitrogen will be mineralized can be difficult, albeit critical to crop performance. Rough guidelines for availability coefficients at various C:N ratios are given in Table 2. The availability of residual compost N to crop plants in the second year after addition is not well-documented. As a general rule, 10 percent of the remaining organic N (after one cropping season) is available for the next crop. Consistent, annual applications of organic matter increase the amount of available nitrogen from compost in the soil.

Table 2. Nutrient Availability Coefficient Guidelines for Composts

C:N Ratio	Nutrient Availability Coefficient		
	N	P	K
< 10:1	0.50	.8	.8
10 to 15:1	0.25	.6	.6
16 to 20:1	0.10	.4	.4
21 to 30:1	0.05	.25	.25
> 30:1	0.00	.10	.10

Information in this article shared from:
Baldwin, K.R. and J.T. Greenfield. 2009. Composting on Organic Farms. 21 p. https://content.ces.ncsu.edu/composting-on-organic-farms

Natural Resource Agriculture & Engineering Service - information from the On-Farm Composting Handbook (NRAES-54), editor: Robert Rynk. https://www.cornellstore.com/PALS-On-Farm-Composting-Handbook-NRAES-54

Session 9

General Vegetables

Session Chair:
Bill Sciarappa

NO ARTICLES SUBMITTED

Session 10

Nursery II

Session Chair:
Timothy Waller

MANAGEMENT OF OOMYCETE ROOT DISEASES

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Phytophthora spp., Pythium spp., and Phytopythium spp. (the water-molds) root diseases are prevalent throughout the entirety of agriculture and can be particularly problematic in ornamental crop production, whether grown in the field or containers. The material outlined below provides insight into cultural practice guidance and well as Oomycide specific material selection considerations (Figure 1).

Be mindful of water –Fast drying medias and soils are less conducive to disease development than those that are wet or waterlogged. Oomycetes (and other root pathogens) often require water for dispersal of their propagules or swimming zoospores and subsequent infection of plant material. This means paying keen attention to not overwatering, mindful of how long plants are staying wet, standing water, and locations of water movement or runoff zones. If you are growing more susceptible species, such as Rhododendrons or conifers, it is important to make sure the field or media is well-drained. Planting on a gentle slope or mound is preferable in both field and container production areas, as this promotes better drainage, evaporation, and airflow. Avoid tightly spaced plants and overgrowth. Avoid over irrigation, especially during spring/fall.

Start clean – stay clean – sell clean, disease-free seedlings. Segregation or quarantine of incoming plants is an often-underutilized production practice. This practice alone could stop a pathogen infestation before it ever gets going and should be taken seriously, especially if plants are headed to a field operation. Only purchase seedlings from reputable nurseries and make sure to carefully inspect the plants upon delivery. Pay careful attention to the roots and crowns of the seedlings and do not plant any material that is suspicious. It is worth rejecting a few plants, than dealing with a perpetual root issue. Keep track of all crop inputs, especially mother-stock if self-propagating material. Phytophthora and other fungi can be spread via both above and below ground materials.

Cleaning and Sanitizing are key in production and plant handling or storage areas, as well as on the equipment and materials used in crop production, irrigation systems, and personnel entrance/egress areas (especially with young plants). Regularly changed foot baths at the entrance/egress of propagation areas are great tools for mitigating devastating pathogen explosions. Cleaning *then* sanitizing is critical as many sanitizing agents break down rapidly when in contact with organic matter, such plant debris. Consider all non-sterile inputs as potential points of contamination or vectors for disease spread. This is especially true for areas with known histories of Oomycete disease presence. Special attention should be paid to the floors, and other structures within that area.

<u>Frequent monitoring</u> is critical to addressing potential issues before they become uncontrollable problems. Scout the fields regularly and train your employees on what they should be looking for, especially in susceptible hosts. Encourage them to report any signs or symptoms that might indicate declining plant health. **Plant health should always be addressed in disease management.**

Figure 1. Oomycete Material Options and Considerations - *focus on Phytophthora and Pythium*

FRAC	**Risk** of promoting pathogen resistence	**Active**(s)	**Example Tradenames 1**	*(Please see each specific label)* **Notes**	**Translocation** Movement within plant
4	High	Mefenoxam	Subdue Maxx, Subdue GR	**See each label.** Typically, spring and fall drench applications at 6lb/A/year (Subdue Maxx). Foliar, drench, soil directed, soiless media incorporation, and chemigation applications. **See label for minimum reapplication intervals for drench applications** (ranging from 3 weeks to 4 months). *Mefenoxam resistenace has been detected in the USA.*	**Xylem mobile systemic -** translocates upwards (acropetal)
2P07	Low	Phosphonates. Aluminum tris (O-ethyl phosphonate)	Areca, Aliette, *generic* fosetyl-Al	**See each label.** Foliar and drench/soil reapplication interval is 30d or greater. **Do not apply group P07 and copper-based fungicides within 14d of one another**	**Fully systemic -** xylem and phloem mobile (amphimobile)
P07	Low	Phosphonates. Mono- and di-potassium acids and salts of phosphorus acid	Alude, Reliant, K-Phite 7LP (newer label)	**See each label.** Generally, soil drench minimum reapplication interval is 30d and foliar applications, less than. **Do not apply group P07 and copper-based fungicides within 14d of one another**	**Fully systemic -** Xylem and phloem mobile (amphimobile)
40	Low to Medium	Dimethomorph, Mandipropamid	Stature SC, Micora	**See each label**. Foliar, drench, soil directed, and chemigation applications.	**Translaminar systemic** - local translocation
40 + 45*	Medium + High*	Dimethomorph + ametoctradin*	Orvego	**See label**. Foliar, drench, soil directed, and chemigation applications.	**Translaminar systemic** - local translocation
21	Medium to High	Cyazofamid	Segway-O, Celoxid SC	**See each label.** Minimum reapplication interval 14 - 21d. No more than 2 applications per crop cycle. Applied as drench or soil directed.	**Protectant** - no systemic activity
49	Medium to High	Oxathiapiprolin	Segovis	**See label** for use restrictions and tank-mix compatibility.	**Xylem mobile systemic -** translocates upwards (acropetal)
11	High	Fenamidone	Fenstop	**See label:** Currently only labeled for greenhouses. Field use label is forthcoming. Reapplication interval is 28d	**Xylem mobile systemic -** translocates upwards (acropetal)
43	Medium	Fluopicolide	Adorn	**See label**. Foliar, drench, and chemigation applications. No more than 2 applications per crop cycle. Minimum reapplication interval - 14d.	**Xylem mobile systemic -** translocates upwards (acropetal)
BM02	*Unknown (likely low)*	Biologicals	Rhapsody (bacteria), Root Sheild Plus (fungi)	**See each label.** Reapplication interval typically rapid at 3-10d.	**Antagonistic -** hinders pathogen colonization of host tissues are rhizosphere (root zone)
-	-	Quaternary ammoniums	KleenGrow, Uptake, Physan 20, Green Shield	**See each label.** Typically used in sanitation efforts, irrgation maintainece (biofilms), and some labels allow for application to plant surfaces. Phytoxicity concerns are rate and label specific. Generally considered broad spectrum fungi/bacteria/oomycete pesticides.	**Direct contact** - varying residual activity, no systemic activity
-	-	Hydrogen dioxides	Zerotol,Oxidate		

Disclaimer - Materials represent examples and do not cover all possible control scenarios. Tradenames listed do not imply endorsement and are used as examples only. You must personally refer to, and strictly follow the label for each compound prior to use - Rutgers is not responsible for misused materials or damages thereof. The label is the law. Labels will provide detailed information on where and how the material can be legally used. Additionally, application intervals, compatibility, surfactant use, and other key information is described in detail. Always discuss treatments with your local agents.

Session 11

Blueberry

Session Chair:
Gary Pavlis

NO ARTICLES SUBMITTED

Session 12

Small Fruit

Session Chair:
Peter Nitzsche

EFFORTS TO RELEASE A SPOTTED-WING DROSOPHILA PARASITOID IN NEW JERSEY

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Spotted-wing drosophila (SWD) is an invasive fruit fly from Southeast Asia that continues to be a major problem in small fruit crops since its arrival in the continental U.S. in California in 2008, and the northeastern U.S. in 2011. Blueberries, raspberries, blackberries, and strawberries are highly preferred hosts and, therefore, especially vulnerable to SWD. The arrival of SWD in the U.S. prompted considerable research activities to develop integrated pest management (IPM) strategies for its management that included biological control. In parts of its native range, SWD is not considered a major pest to some extent because it has effective biological control agents that keep its numbers low. However, SWD lacks these natural enemies in the invaded ranges such as in the U.S. For instance, SWD larvae have a strong immune mechanism that allows them to avoid being attacked by the parasitoids present in these invaded ranges.

As part of a biological control program, efforts were taken by personnel at the USDA's Beneficial Insects Introduction Research Unit in Newark, DE to identify natural enemies that could be safely introduced to the U.S. In particular, the parasitoid *Ganaspis brasiliensis*, a tiny wasp native to Asia where SWD comes from, was found to be a good candidate because of its narrow host range. A permit to release *G. brasiliensis* in the U.S. was approved in the fall of 2019. Interestingly, in 2019, this wasp was found inadvertently in British Columbia, and in 2021, it was found in Washington State. Female wasps lay an egg in SWD larvae which then pupate, but instead of an adult SWD emerging from the pupa, an adult wasp emerges. Thus, this wasp is well adapted and specific to attack SWD larvae and, unlike the larval parasitoids already present in the U.S., can overcome their immune response.

Our goal is to release *G. brasiliensis* wasps in wooded areas on farms with wild host plants, where SWD overwinters and disperses from in the spring. We expect that if *G. brasiliensis* is able to establish and successfully parasitize SWD in these 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.

Efforts to release *Ganaspis brasiliensis* in New Jersey

In a coordinated effort between Rutgers University and the NJ Department of Agriculture Phillip Alampi Beneficial Insect Rearing Laboratory, a total of 1000 *G. brasiliensis* wasps were released per farm on five commercial blueberry farms in Atlantic and Burlington Counties (see pictures). Releases took place in July and August 2022. Parasitoid surveys were conducted prior to the release of *G. 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 from both baited traps and wild berries. These results show that *G. brasiliensis* was successful at surviving at least during the first months after release. Samplings during the spring of 2023 are needed to show the winter survival.

Future Plans

We plan to conduct studies on *G. brasiliensis* overwintering biology and on future releases and monitoring its establishment in New Jersey. Starting in December of 2022 until May of 2023, an overwintering experiment will be performed to study the survival of *G. brasiliensis* under 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.

Pictures showing mass releases of the SWD parasitoid *Ganaspis brasiliensis* near blueberry farms in southern New Jersey. Photos by Patricia Prade.

Acknowledgements

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Session 13

Succession, Transition, and Estate Planning/Asset Protection

Session Chair:
Robin Brumfield

NO ARTICLES SUBMITTED

Session 14

Specialty and Niche Crops

Session Chair:
William Sciarappa

RUTGERS HABANEROS AND BIODEGRADABLE MULCH PROJECT

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INTRODUCTION – Peppers are a large market in 11 states. NJ farmers produce approximately 105 million pounds annually on 3,800 acres. These growing systems primarily are placed on mounded black plasticulture with drip irrigation as is done similarly on several other fruiting crops. Peppers serve as an ideal example of plastic performance of these high-value crops – tomato, eggplant, watermelon, strawberry, etc.

New generations of non-petroleum based plastics are being commercialized at competitive prices. Soil health benefits may include not breaking down into microplastics – an increasing threat to our food chain. Also noted are not having disposal costs. Biological breakdown by the soil food web may decompose these plant-based products with novel catalysts which may be organically approved as well.

GOALS AND OBJECTIVES – New biodegradable mulch films may represent drop-in replacement technology to solve economic and environmental limitations with improved physical and optical properties. This field study was to document required physical properties, their retention and overall performance of standard vs. biodegradable mulch films during the crop growth cycle and beyond. Objectives measure/compare physical, chemical, biological and agricultural parameters. Performance parameters include weed suppression, soil moisture over time, fertilizer retention, crop quality and crop yield as well as any film degradation after harvest (6-12 months).

MATERIALS & METHODS - At Rutgers Horticultural Farm 3 in East Brunswick, we used habanero peppers as a representative stand-in for tomato, eggplant, strawberry and other fruiting crops. Flats of six habanero cultivars were grown in the nearby NJAES greenhouses on Cook Campus including four commercial varieties and two Rutgers cultivars – Rosebell Red® and Pumpkin Habanero®.

Rolls of black plastic film of an experimental bio-plastic mulch film were compared to a commercial biodegradable mulch film BioGold® and to the standard black petroleum based plasticulture used for fruiting vegetables. Pilot quantities of the experimental black mulch film were manufactured 18-25 microns thick, in 4-foot rolls,1000 feet long.

<u>Physical</u> - Soil temperature taken at 4” depth, covering surface and air temperatures at 4 feet height. Lumens of light under the canopy and at the top of the plant.
<u>Chemical</u> - Soil samples were collected before transplanting and after harvest to include pH, Soil Organic Matter, Macronutrients (NPK) and Micronutrients

Biological - Soil microbial respiration with the Solvita® soil health kit. Foliar chlorophyll analysis of young leaves with the Apogee® portable leaf test system.
Agricultural - Plant growth/height and maturity were measured several times per month as a measure of crop health. Biomass yields of the entire plant were taken and yield measurements of fruit load weights per size category, maturity, and capsaicin levels.

EXPERIMENTAL DESIGN

ROWS S TO N	PLASTIC TYPE						
A	BIOGOLD A	RR	SB	RR	SB	RR	G
B	BIOGOLD B	P	GH	P	GH	P	RH
C	EXPERIMENTAL C	RR	SB	RR	SB	RR	G
D	EXPERIMENTAL D	RR	SB	RR	SB	RR	G
E	STANDARD E	RR	SB	RR	SB	RR	G

EACH PLOT IS 20 FEET IN LENGTH FOLLOWED BY A 5 FOOT SPACE - NO PLANTS.

CULTIVARS RR = RU ROSEBELL RED, SB = SCOTCH BONNET, GH = GREEN HABANERO, RH = RED HABANERO, G = GASKO EXTREME, P = RU PUMPKIN HABANERO

PRELIMINARY RESULTS

Physical - Seasonal Temperatures - Air, Cover surface and 4 inch soil sub-surface as well as seasonal degradation, soil moisture, & light range for 5 months on 5 plasticulture treatments showed little significant differences.

Chemical – Soil acidity, macronutrients and micronutrients show minor differences.

Biological – Populations of beneficial microorganisms preliminarily show higher levels of CO_2 respiration under biodegradable mulches compared to standard. Populations of various weeds remain low and only grow in small rips/tears created by wildlife.

Agricultural - A trend was noted in overall varietal biomass totals with Experimental row C and Bio-Gold row B having higher overall yields with Wet Weight totals over 70 pounds per 3 entire plants of each 6 varieties in 150 ft. of a single covered row. Fruit weights within that composite measure over 40 lbs. total for 18 plants total per row harvest.

ACKNOWLEDGEMENTS – This project was conducted under a Rutgers grant. We appreciate the help and guidance provided by the Rutgers team: Dr. Jim Simon, Farm Manager John Bombardiere, Ph.D. candidate Tori Rosen, Rutgers student R&D staff, Peter Mahoney, Claire Chapeau, Trevor Styles and RU-SEBS student volunteers.

PERFORMANCE OF ETHNIC CROPS GROWN UNDER BLACK AND WHITE-OVER-BLACK PLASTIC MULCHES IN CENTRAL NEW JERSEY

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Abstract
Habanero peppers (*Capsicum chinense,* Rutgers Pumpkin Habanero and Rutgers Rosebell Red), roselle (*Hibiscus sabdariffa*-IRR selection) and tropical spinach (*Amaranthus* spp.-TS-RS selection)) were evaluated under black (BPM) and white-over-black (WPM) plastic mulches at Specca Farms Pick-Your-Own, Bordentown, New Jersey in 2021 and 2022. Results showed that the ethnic crops evaluated varied in their responses to mulch type. The habanero peppers yielded less marketable fruit under BPM (30.9% less) in 2021 than under WPM and more than under WPM (24.6% more) in 2022. Roselle consistently produced higher yields under WPM, ranging from 12-17% increase in marketable foliage compared to yield under BPM. Tropical spinach (TS-RS) produced more marketable foliage under BPM (46.2% higher) than under WPM in 2021 but less under BPM (23.3% less) than under WPM in 2022. Since there is insignificant difference in the cost of the two plastic mulch types, the use of WPM is recommended for the cultivation of roselle under Central New Jersey conditions. The inconsistencies observed in habanero and tropical spinach responses to mulch type need further investigation for future recommendations.

Introduction:
Ethnic crops are gaining prominence in New Jersey due to the rising ethnic populations in the state and the rest of the United States. By 2042, it is estimated that the ethnic minority population will supersede the white majority. The ethnic population influx is expected to drive an increasing demand for ethnic crops in New Jersey and the rest of the country. There is limited information on the cultural practices that optimize the performance of these crops in our agroecosystems. It is therefore essential that data be generated to understand the cultural applications that favor optimum performance, so we may transfer this information to the growers for increased productivity and enhanced profitability. Vegetable production under plastic mulch is a common cultural operation that reduces weed management costs and conserves soil moisture in drip irrigation systems. Other advantages connected to heat conservation/dissipation and light reflections/absorption in plastic mulch cultivation systems have also been suggested. Black (BPM) and white-over-black (WPM) plastic mulches are commonly applied in vegetable cultivation in New Jersey. The objective of this study was to evaluate selected ethnic crops under the two mulch types to determine which option works better for field production in Central New Jersey.

Materials and Methods
Experiments were conducted between late May and October in 2021 and 2022 at Specca Farms Pick-Your-Own, Bordentown (40.14^{O}N, 74.41^{O}W) New Jersey, to evaluate the performance of Rutgers released habanero peppers (Rosebell Red and Pumpkin Habanero), roselle (Indian Red-Red or IRR) and tropical spinach (TS-RS or Asian Red Stripe). Six- to eight-week-old transplants of habanero and roselle were used to raise the crops in 2-1/2-ft wide raised (6-inch) seedbeds covered with black (BPM) or white-over-black (WPM) plastic mulch. Habaneros and roselle were planted in a single row and spaced 24 inches along the center of the seedbed, while tropical spinach seed was sown in single row along the center of the seedbed. Plot sizes varied from year to year, but plot replication was maintained at three per treatment. Natural rain was supplemented with drip irrigation as needed. Inter-row weeds were controlled with Roundup (glyphosate) herbicide about four weeks after transplanting/sowing. Insect and disease problems were minimal or non-existent for the habanero peppers and roselle. In tropical spinach, leaf feeding insects were controlled with three weekly applications of Sevin (Carbaryl) insecticide beginning after the second harvest of marketable foliage about eight weeks after sowing. The data collected focused on the marketable portion of the ethnic crops, namely red ripe/mature green fruit for the habaneros, and marketable foliage for roselle and spinach. All harvesting was done manually. Tropical spinach harvest commenced 4-5 weeks after sowing and continued every 10-15 days after the last harvest until the plants started to flower. Roselle harvesting started about eight weeks after planting and continued every 18-21 days after the last harvest until the frost killed the plants in late October or early November. Habanero pepper harvest started in the last week of August in 2021 and first week of September in 2022. Three rounds of harvesting were done spaced three weeks apart between August/September and late October. For all the crops, fresh weights were taken in the field shortly after harvest. Yields were compared statistically to determine differences between the treatments.

Results and Discussion:
Habanero peppers were highly productive in 2021 with superior yield produced under WPM compared to BPM. In 2022 the habaneros yielded less than in 2021 and the result was opposite what occurred in 2021 (Table 1) The two habanero peppers both responded the same way to plastic mulch type in 2021 and 2022. For both peppers yields were higher under WPM in 2021 but higher under BPM in 2022. (Table 1). Roselle consistently produced higher marketable foliage under WPM than under BPM both in 2021 and 2022 (Table 2). Like habanero peppers, tropical spinach was inconsistent in its response to plastic mulch type. In 2021, higher yield was observed under BPM but in 2022, the reverse occurred (Table 3). The inconsistency in the response of habanero and tropical spinach to mulch type demands further investigation to determine the other factors that may be playing a significant role in these mulch systems. We suspected soil fertility variations may be a factor to consider. Roselle consistently showed that cultivation under WPM enhances the marketable foliage. For growers, it would be expedient to consider using the WPM for leaf production. More work is needed to confirm mulch type recommendation for habanero and tropical spinach production in Central New Jersey.

Table 1: Habanero peppers at Specca Farms: Marketable fruit yield (lb)

Year	Variety	BPM	WPM	Yield difference (%)
2021 (From six stands and three harvests/plot)	Rosebell Red	32.6	49.4	51.5
	Pumpkin Habanero	37.4	41.2	10.2
2022 (From 5 stands and three harvests/plot)	Rosebell Red	17.9	15.9	-11.2
	Pumpkin Habanero	24.3	15.1	-37.9

BPM=Black Plastic Mulch; WPM = White-over-Black Plastic Mulch; Yield difference uses yield under BPM as reference.

Table 2: Roselle at Specca Farms: Marketable foliage yield (lb)

Year	BPM	WPM	Yield Difference (%)
2021 (from 9 stands)	16	18	12.5
2022 (from 32 stands)	133	156	17.3

BPM=Black Plastic Mulch; WPM = White-over-Black Plastic Mulch; Yield difference uses yield under BPM as reference

Table 3. Tropical spinach at Specca Farms: Marketable foliage yield (lb)

Year	BPM	WPM	Yield difference (%)
2021 (two harvests from 5 stands/plot)	2.6	1.4	-46.2
2022 (Five harvests from 12 stands/plot)	146.2	180.2	+23.3

BPM=Black Plastic Mulch; WPM = White-over-Black Plastic Mulch; Yield difference uses yield under BPM as reference

Acknowledgement

Specca Farms Pick Your Own farm crew was fully responsible for managing the plots used for the experiments reported in this paper and we are greatly indebted to them for their commitment to the success of the study.

GROWING GINGER AND TURMERIC

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Ginger (*Zingiber officinale*) is a perennial plant that is native to tropical regions of Asia and is grown commercially as an annual crop. Ginger is commonly used in many African, Asian, and Caribbean recipes or in herbal teas, and is sold fresh or dried and ground. What many people refer to as the "ginger root" is actually the "ginger rhizome," which refers to the underground stem of the plant. The continental United States imports most of its ginger from other countries, or from Hawaii, but ginger can also be grown locally right here in New Jersey. Turmeric (*Curcuma longa*) is a close relative of ginger that has gained popularity due to its health benefits and has similar growing requirements as ginger.

Recently, farmers throughout the Northeast have experienced success growing baby ginger and turmeric in high tunnels. In order to develop best management practices for growing these crops in NJ, field trials have been conducted at the Cream Ridge Specialty Crop Research and Experiment Center. These trials documented production practices for growing baby ginger (var. Peruvian Yellow) and Turmeric (var. Hawaiian Red) in Central New Jersey.

Pre-sprouting the Seed Pieces

Ginger and turmeric require a long growing season to produce a harvestable crop. In New Jersey, this involves pre-sprouting the 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 or turmeric, each seed piece is spread out in a single layer in flats and covered with 1-2" of potting mix. In our trials, the temperature in the greenhouse was maintained at approximately 75°F and the flats were placed on heat mats set to 72°F to maintain an even and consistent temperature in the root zone. The medium in the sprouting trays should be supplied with adequate moisture but never over-watered. Shoots will emerge out of the medium and roots will develop over an 8-week period. Turmeric is generally slower to break dormancy than ginger and may require a longer period of time for pre-sprouting.

Planting the Seed Pieces in the High Tunnel

When soil temperatures in the high tunnel are consistently 55°F or higher, the sprouted seed pieces can be planted into the soil. This is likely to be in early to mid-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 to fully develop.

Sprouted ginger and turmeric seed pieces should be planted 6 to 8 inches apart and 8 inches deep into trenches spaced 2 feet apart, then lightly covered with a few inches of soil so that the tips of the shoots are still showing. Thirty pounds of ginger seed will plant approximately 100 to 180 row feet depending on the size of the seed pieces. Turmeric seed is generally smaller and may plant more row feet per pound than ginger.

A light layer of straw mulch and drip irrigation will help to ensure that adequate moisture is supplied, while minimizing major fluctuations in soil moisture and temperature levels. Irrigation should be relatively light to minimize pathogen development, and well-drained soils are preferred. The plants should also be hilled two times throughout the growing season as the shoots grow taller and the underground rhizomes begin to develop. This is a similar process to hilling potatoes, so that sunlight does not discolor the rhizomes.

Disease Management

Ginger is susceptible to bacterial wilt (*Ralstonia*), bacterial soft rot (*Erwinia*), *Pythium*, *Rhizoctonia*, and *Fusarium*., and soil-borne nematodes. Purchasing disease-free seed stock is the first line of defense against these problems. 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. Moveable high tunnels allow the crop to be rotated from one section of the field to another each year, further helping to reduce the buildup of soil-borne pathogens.

Harvesting Ginger

Ginger is generally harvested from late September or early October through the beginning of November. The leaves will begin to turn brown as temperatures drop and frost begins to occur. Ginger plants can remain in the ground as long as there is at least one inch of green tissue still living above the rhizome, but many growers will harvest sooner. 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. Baby ginger is perishable and will store for about two weeks in cold storage.

In our trials, harvested ginger yields ranged from 2.1 to 2.7 lbs. per foot during a four-week harvest period starting in early October. The total harvested yield for Peruvian Yellow baby ginger was 384.5 lbs. from 26 lbs. of seed planted in 160 row feet. This equates to 14.8 lbs. harvested for every 1 lb. planted and approximately 2.4 lbs. of ginger harvested per foot. 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 over $38 per linear foot of bed space planted, making it a potentially very valuable crop for NJ growers who are involved in direct market sales. In our trials, turmeric yields were lower compared to ginger, averaging 0.85 lbs. per foot and yielding a total of 51 lbs. harvested from 10 lbs. planted. This equates to a return of 5.1 lbs. harvested for every 1 lb. planted. Fresh turmeric retails for approximately $10 per pound, suggesting gross returns of $8.50 per row foot for baby turmeric.

Baby ginger and turmeric are two new specialty crops that can be produced in high tunnels in NJ. Future work should focus on trialing additional cultivars, fine-tuning timing and fertility recommendations, and developing effective controls for the soil -borne pathogens that may affect these crops.

Additional Resources

Ginger and Turmeric. University of Kentucky Cooperative Extension: https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/ginger_turmeric.pdf

Effects of early season heating, low tunnels, and harvest time on ginger yields in NH, 2017: https://extension.unh.edu/resources/files/Resource007161_Rep10344.pdf

Session 15

Food Safety

Session Chair:
Meredith Melendez

ON-FARM RECORDKEEPING TIPS AND TOOLS

Meredith Melendez

Rutgers Cooperative Extension of Mercer County Agricultural Agent

Compliance with food safety regulations and buyer requirements increases the number of records that farmers need to keep up to day on a regular basis. These records become an important part of the farm management process, and evidence that specific practices were completed. The post-farm visit survey, completed nationally after a voluntary On-Farm Readiness Review is completed, showed that:

- 39% of participant farms were deficient in their health and hygiene training records
- 30% of participant farms were deficient in their harvest cleaning and sanitation records
- 25% of participant farms were deficient in their postharvest cleaning and sanitation records

Inspectors and third-party auditors rely on these records of evidence that appropriate steps were taken to reduce human pathogen risks, show the process that is used to reduce risks, and show when and how corrective actions were used.

Farms should determine what records they are already keeping, the records that they should be keeping based on inspections and audits, and any additional records that they may want to keep for better business management. Farms should consider their certifications, state and local requirements, Federal requirements, and buyer requirements when coming up with the list of records to keep.

Some records do not have to be generated on the farm to be considered official by an outside entity, this could include lab analysis reports, product labels, service records, and invoices for materials purchased. Records generated on the farm should include:

- The farm name
- The actual values and observations made during monitoring
- Any corrective actions that may have taken place
- Adequate description of the commodity impacted and the growing location
- Date and time of the activity documented
- Accurate, legible, and indelible writing
- Signed, or initialed by the person completing the activity
- Reviewed, dated, signed within a reasonable time by a supervisor or responsible party

Some tips for making record keeping a bit easier at the farm:

- Standardize the format of your records across the farm when possible
- Include record keeping in employee job descriptions to delegate responsibility
- Provide record keeping information to employees during training
- Consider your records when you add new commodities, purchase new equipment, fix or tweak existing equipment
- Communicate with those who are keeping the records to verify they are working
- Review your records regularly to make sure that they are working as they should
- Use your records to help identify problems and lead to corrective actions
- Be prepared to make changes as you go

The FSMA Produce Safety Rule requires the following records be kept if covered by the rule and not qualified exempt:

- Personnel qualifications and training
- Water system inspection
- Water treatment monitoring
- Agricultural water die-off corrective actions
- Agricultural water
- Biological soil amendments of animal origin
- Equipment, tools, buildings, and sanitation

Farms that are covered by the rule but are qualified exempt must be able to provide records to prove this. Record templates have been made available from the Produce Safety Alliance and are available online through the QR code.

Additional resources can be found online:
Digital Recordkeeping with Google Docs - Michigan State

Organic and FSMA PSR Recordkeeping – CAFF

FOOD SAFETY MODERNATION ACT PRODUCE SAFETY RULE: NEW REGULATIONS THAT WILL IMPACT YOUR PRODUCE OPERATION

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Harvest and Post-Harvest Agricultural Water Requirements

The water rule under the Food Safety Modernization Rule (FSMA) Produce Safety Rule (PSR) has been under review for some time. The Food and Drug Administration (FDA) has finalized the harvest and post-harvest water which includes water used during harvest, for hand washing, cleaning equipment, cooling, and cleaning produce.

As with other FSMA rules, the FDA plans to take an "educate before and while we regulate" posture as they begin implementing the harvest and post-harvest requirements. For the first year of compliance, the FDA intends to work closely with state, regulatory, and industry partners to advance training, technical assistance, educational visits, and on-farm readiness reviews to prepare both growers and state regulators for implementing these provisions prior to initiating routine inspections. The harvest and post-harvest rule go into effect on the following dates:

- January 26, 2023, for all farms with sales over $500,000.
- January 26, 2024, for small businesses (total sales more than $250,00 but less than $500,000); and
- January 26, 2025, for very small businesses (total sales more than $25,000 but less than $250,000);

Growers are required to test ground water sources (wells) 4 times in the first year and once each year thereafter. If the water does not meet acceptable levels (non-detectable generic E. coli) the farm would need to stop using the source and determine the cause, make corrections then return to testing 4 times. If a municipal water source is used the report from the municipality testing program is sufficient.

Growers will also need to do a water distribution inspection each year that evaluates the water source, connections going into harvest or post-harvest systems and any water delivery systems in a packing house. Records will need to be maintained for two years showing the inspection results. There will be more details presented at the New Jersey Agricultural Convention & Trade Show at Harrah's Resort in Atlantic City February 8, 2023, during the afternoon food safety session.

Pre-Harvest (Irrigation) Agricultural Water Requirements

It is not yet known when the pre-harvest rule will be finalized. However, when the proposed rule is finalized, it will require farms to conduct an annual systems based agricultural water assessment to determine and guide measures to minimize potential risks associated with pre-harvest agricultural water. When the rule is finalized, FDA proposes the following compliance dates:

- Nine months after the effective date for all other businesses (farms over $500,000);
- One year, nine months after the effective date for small businesses (farms more than $250,00 to $500,000); and
- Two years, nine months after the effective date for very small businesses (farms more than $25,000 to $250,000).

Requirements for Additional Traceability Records for Certain Foods

The FDA has finalized traceability requirements under FSMA. The rule takes effect January 20, 2023, but enforcement will be delayed until January 20, 2026. All operations will need to start complying on that date. Operations with sales of less than $25,000 on average over the last 3 years adjusted for inflation based on 2020 are exempt. If a grower is exempt from the FSMA: PSR based on sales under $25,000 it is also exempt from the traceability rule. Growers who sell directly to consumers, sell food to institution programs, produce certain foods that are packaged on a farm, grow food that is rarely consumed raw or grow food that receives certain types of processing are exempt. If a grower sells wholesale and direct to consumer, the wholesale product may fall under the traceability rule.

FDA has developed a "Food Traceability List (FTL)" which is a list of foods for which additional traceability records are required to be maintained. In New Jersey it covers most of what is grown such as fresh cucumbers, herbs, leafy greens, melons, peppers, etc. unless it is considered rarely consumed raw.

Records must be maintained for every "Critical Tracking Event (CTE)" which is an event in the supply chain of a food involving the harvesting, cooling or initial packing of a raw agricultural commodity. Along with the CTE are "Key Data Elements (KDE)" which is the information which must be maintained. So what records are required?

- The commodity at harvest
- Quantity and unit of measure of the food harvested (boxes, pounds, etc.)
- Name of the field or growing area including map coordinates
- The date of harvest
- Farm name, address and phone number of the operation

For growers who fall under the rule a traceability plan is required which includes:

- How the records are maintained including the format and location of the records
- Description of the procedures used to identify foods on the FTL list
- Description how traceability lot codes are assigned
- Contact person who manages the records
- Farm map showing the areas where commodities are grown and name of each field including coordinates
- Plans must be retained for 2 years.

Lot codes will need to be assigned when the commodity is packed. The same lot code will be used throughout the marketing system. These lot code numbers do not need to be attached to each box or container. They do need to be on a bill of lading, invoice, etc.

The next three years will be a learning experience for growers, extension educators and regulators. There are many details in the rule which are not clear even after reading it more than once. At the Vegetable Growers meeting we will review the latest interpretation of the rule and discuss which records will be required. For anyone who wants more details go to: https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-final-rule-requirements-additional-traceability-records-certain-foods

FSMA PSR INSPECTION UPDATE

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In recent years, food safety issues have risen to a new level of importance across the country. The CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) get sick, 128,000 are hospitalized, and 3,000 die each year from foodborne diseases.

The Food and Drug Administration (FDA) considers this a significant public health burden that is largely preventable. The Food Safety Modernization Act (FSMA) has shifted the focus from responding to foodborne illness to preventing it. The FDA has finalized seven major rules to implement FSMA including the “Produce Safety Rule” and “Preventive Controls for Human Food” which directly affect farmers and food processors who constitute a significant portion of the state’s food and agriculture complex.

The 21 CFR 112 Produce Safety Rule (PSR) is one rule of FSMA which uses science-based standards for the safe growing, harvesting, packing and holding of fruits and vegetables for human consumption. The PSR provides the FDA the opportunity to work with the produce industry and state regulatory partners to focus on implementation of food safety on farms.

FDA has partnered with interested states to distribute federal grant funds with the intent of establishing grower education and state-run inspection systems. The NJDA coordinates with Rutgers Cooperative Extension to deliver PSA Grower Training and On-Farm Readiness Reviews. The NJDA currently employs six inspectors and we have identified the following issues commonly encountered on produce farms.

The PSR requires each farm to have at least one individual complete PSA Grower Training or the equivalent as acceptable to the FDA. There must be an assigned Food Safety Supervisor who oversees all food safety operations. You are not required to have a written food safety plan.

All employees, including family members, must receive training in farm food safety, upon hiring, and periodically retrained as needed, at least annually. Training videos in English and Spanish are available on YouTube. Worker training records are required.

Cleaning and sanitizing of food contact surfaces is required. You must also maintain and clean all non-food contact surfaces of equipment and tools. You must use food-safe, EPA approved products and follow the label. Records are required.

The PSR states that you must provide personnel with adequate, readily accessible toilet and handwashing facilities. Handwashing stations must be supplied with soap, water that has no detectable generic E. coli, single-use towels, a trash receptacle and container for disposal for wastewater. Hand sanitizer is not an acceptable substitute. You must have a plan for an unintended porta pot spill.

Contamination can occur from animal intrusion in the fields, storage and production areas. Monitoring and mitigation practices include preharvest field assessments, rodent and bird control plans, and safe storage of harvest and packing materials.

Inspections for Harvest and Post-Harvest water will begin next year on large farms. Inspections for Pre-Harvest water (irrigation, sprays, etc.) will follow the effective date of the rule. Harvest and post-harvest water may be used for washing or cooling produce, on food contact surfaces, and includes hand wash water. You will not receive a separate inspection for Harvest and Post-Harvest water. This area will be addressed during your next Routine inspection. Your inspector will evaluate your practices in regard to the requirements for compliance in this area.

Farms with an average monetary value of produce sold during the previous 3-year period of less than $25,000 (adjusted for inflation) are exempt from PSR Inspections. For Qualified Exempt status the average annual monetary value of all food the farm sold, during the previous 3-year period, directly to qualified end-users, must exceed that of the food sold to all other buyers during that period; and the average annual monetary value of the food the farm sold in the 3-year period proceeding the applicable calendar year was less than $500,000 (adjusted for inflation). You are required to complete an annual assessment and keep the three previous years records and receipts to demonstrate that you qualify for this exemption.

Although some farms are exempt from the PSR Inspections, all produce farms are responsible for implementing food safety. PSA Grower Training, Audit Trainings and outreach are available to all of our farms, whether they are covered by the rule or not.

Many growers question if they are required to have a PSR Inspection if they already undergo Third Party Audits. The answer is yes, because the PSR is a federal code of regulations (law), which mandates inspections for covered farms. In contrast, audits are voluntary, and more narrowly focused. For example, an audit may address one crop or farm area, whereas the PSR Inspection addresses all covered crops and the entire farm operation.

PSR Inspections began in 2019, and in the last 4 years the NJDA has conducted nearly 300 inspections on New Jersey farms. The farm’s first inspection was Initial or “educational” in nature, as directed by the FDA to “educate while we regulate”. This year we began Routine Inspections on large farms, during which we revisited the observations noted on the farm’s Initial Inspection reports. We are happy to report that much progress has been made in terms of education and implementation of food safety on our farms.

Session 16

Creative Marketing and Agritourism

Session Chair:
William Hlubik

ETHNIC CROPS AND ORGANIC WILD-CRAFTING TO ENHANCE CUSTOMER DIVERSITY AND MARKETING POTENTIAL

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It can sometimes feel like there is no place in the modern world for small United States (US) farms in a market place filled with products from very large-scale farms and products imported from countries with much lower labor costs than the US. Two ways small and mid-size farms in the mid-Atlantic region can compete is by specializing in hard-to-find niche crops that are of special interest to specific ethnic groups in the region and by taking advantage of plants already thriving on your farm by wild-crafting.

Ethnic Crops

Ethnic crops, defined as non-mainstream crops brought to, eaten and cultivated in the US by ethnic nationalities from different parts of the world, have been part of US culture since its founding. As the demographics of the US have changed, what vegetables and fruits are considered main-stream have changed. Wave after wave of immigrants to the US have each brought their favorite foods with them and are a potential market for new fresh vegetable crops that are used in these foods. If farmers consider vegetables that are not commonly grown in the US but are sought after by specific ethnic groups they can often find a unique niche market.

Wild-Crafting

There are often sections of land that are part of a farm but are not suitable for vegetable and fruit production or are not being farmed for soil conservation reasons such as hedgerows, woodlots, steep slopes, low lands prone to periodic flooding and wetlands. Wild-crafting, the harvesting of wild crops to sell, allows these areas to be looked at as an additional income source for the farm. The USDA defines a wild crop as any plant or portion of a plant that is collected or harvested from a site that is not maintained under cultivation or other agricultural management. Examples of commonly wild-crafted wild crops include but are not limited to mushrooms, herbs, kelp, blueberries, maple syrup, and ginseng. In 2011 the USDA National Organic Program (NOP) published guidance on wild-crafting which allows wild-crafted items to be certified organic. While wild-crafted items will not usually be able to be harvested intensely without lowering future harvests in many situations wild-crafting can be done profitably as the labor costs are usually limited to harvesting and post-harvest processing. If farmers are not interested in wild-crafting it is also possible to write a harvest agreement with a wild-crafter where they pay to have exclusive access to an area for wild-crafting or foraging for their own use. While an exclusive use agreement with a wild-crafter might seem unusual it is very similar to agreements many farmers already have giving hunters exclusive hunting rights to certain areas. Contracting with a wild-crafter allows for a small income from unfarmed areas with minimal to no work on the part of the farmer.

Ethic crop and Wild-Crafting case study: Snapping Turtle Farm

Snapping Turtle Farm (STF) is a 78-acre certified organic vegetable and herb farm located in Middlesex County New Jersey. The farm is made up of 38 acres of tillable land and 40 acres of lowland forest, wetlands, and rivers. STF sells the majority of its production directly to consumers via regional farmers markets and a box-a-week subscription program. The location of the farm in ethnically diverse central New Jersey and the farm's unique makeup of large amounts of land not suitable for cultivation led the owner Allison Akbay to look at expanding production into ethnic crops and wild-crafting.

The choice to expand into ethnic crop was based on the fact that Middlesex County has a growing Asian community as shown by the US census. The 2020 census showed 26.5% of Middlesex county's population identifying themselves as Asian up from 14% in 2000. Given this demographic shift STF started adding crops that are popular in South Asian and East Asian cuisine and culture to the diverse vegetables and herbs that it already grew. Lack of certified organic seed for some Asian vegetables and herbs varieties has been a problem for STF because the NOP guidelines require that certified organic seed be used whenever possible. There are few certified organic sellers of Asian vegetable varieties in the US leading STF to have source from multiple organic seed companies across the US. On occasion STF has had to purchase untreated conventionally produced seeds after documenting lack of availability of organic seeds as required by the NOP. Another challenge faced by STF was the fact that information on growing many ethnic crops is not available for the mid-Atlantic region. While this initially seemed to be a challenge it turned into an unexpected marketing opportunity as it led STF's owner to start speaking in person and on social media to small scale growers for their experience growing the new vegetables. This information about STF growing difficult to find vegetables spread through the local Asian community bringing many new customers to STF's farmers market booths. Vegetables grown specifically targeting the Asian community now make up 10% of all gross sales made by STF. The farms plans to increase the varieties of crops that are of specific interest to the local South Asian and East Asian customers.

Crops grown in the 2022 season due to interest of the South Asian and East Asian communities in Middlesex County, New Jersey	
Crop's Common Name	**Botanical Name**
Bitter melon (Tai Guo variety, smooth light green)	*Momordica charantia,* var. *Tai Guo*
Bitter melon (Indian variety, spiked dark green)	*Momordica charantia*
Pak choy	*Brassica rapa, ssp chinensis*
Bottle gourd (fresh vegetable, not dried)	*Lagenaria siceraria*
Edamame (fresh soy bean)	*Glycine max,* var. *midori giant*
Eggplant (udumalpet variety)	*Solanum melongena,* var. *Udumalpet*
Holy basil green (Ram variety, sold as live plant)	*Ocimum africanum*
Holy basil red (Krishna variety, sold as live plant)	*Ocimum tenuiflorum,* var. *Krishna*
Lambsquarters	*Chenopodium album*
Malabar spinach	*Basella alba*
Okra	*Abelmoschus esculentus*
Thai basil	*Ocimum basilicum,* var. *Sweet Thai*
Thai chile	Capsicum annuum, var. *Thai hot*
Note: all of the above were field grown with the exception of Holy Basil which customers requested as a live plant.	

New Crops that will be trialed in the 2023 season due to interest of the South Asian and East Asian communities in Middlesex County, New Jersey	
Crop's Common Name	**Botanical Name**
Fenugreek	*Trigonella foenum-graecum*
Napa Cabbage	*Brassica rapa, ssp chinensis*
Red Roselle / Red Sorrel	*Hibiscus sabdariffa*
Ridge gourd / Ridged Luffa	*Luffa acutangular*
Sponge gourd / Smooth luffa	*Luffa aegyptiaca or L. cylindrica*

STF includes 40 acres of land that are lowland forest, wetlands, and rivers and thus not available for cultivation. The forested areas are under a forestry management plan that includes yearly firewood harvest. When looking for additional ways to make this land profitable STF turned to wildcrafting. STF harvests berries, nuts, flowers, herbs, and mushrooms from these parts of the farm not under cultivation. STF has had all areas of the farm certified under the National Organic Program and a wildcrafting plan is submitted as part of the yearly organic certification so all wildcrafted crops can be sold as USDA certified organic. The organic certification of the wildcrafting area has also led to an agreement with STF and another organic farmer that does not have a wildcrafting area on their farm. The farmer pays by weight for what they harvest from STF which they then use in a certified organic tea blend. The gross sales of wildcrafted items from STF is currently relatively small at 2% of total gross yearly sales but because wild crafted crops do not need to be planted and managed like traditional crops the harvest and processing only used 0.07% farm man hours in 2022. STF hopes to continue to expand wildcrafting in the future.

Wilcrafted crops 2022 Season	
Mulberry	*Morus*
Lambsquarters	*Chenopodium album*
Cherry branches (sold as forced flowers in the winter)	*Prunus spp.*
Forsythia branches (sold as forced flowers in the winter)	*Forsythia*
Purslane	*Portulacaceae*
Mushroom, Chicken-of-the-Woods	*Laetiporus sulphureus*
Mushroom, Hen-of-the-Woods	*Grifola frondosa*
Yarrow (sold as live plant)	*Achillea millefolium*
Black walnut	*Juglans nigra*
Common Milkweed (sold as live plant)	*Asclepias syriaca*
Mullein	*Verbascum thapsus*

Session 17

Weed Science – Managing Herbicide Resistance

Session Chair:
Thierry Besancon

ORIGIN AND MECHANISMS OF HERBICIDE RESISTANCE IN WEEDS

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Herbicide resistant weeds evolve worldwide from selection pressure caused by the repeated use of herbicides with the same mechanism of action (MOA) in conventional crop cultivars. Currently, herbicide resistance has been reported in 267 species of weeds worldwide and affects 97 crops in 72 countries. Overall, weeds have evolved resistance to 27 of the 31 known herbicide sites of action for a total of 165 different herbicides (Heap 2022). The greatest number of herbicide-resistant weed species is reported for the ALS-inhibitor, triazine, and ACCase-inhibitor herbicides. The continual development of herbicide-resistant weed biotypes poses a direct threat to the sustainability and the long-term survival of current cropping systems.

How Does Herbicide Resistance Develop?

Herbicide resistance is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In simple terms, herbicide resistance refers to a situation where an herbicide no longer controls a weed population that was once controlled by the same herbicide. By exerting selection pressure on weed populations, herbicides will select for rare plants that have natural genetic resistance (biotypes) to a specific herbicide MOA. If the selection pressure is maintained over the course of several weed generations, the populations of the herbicide resistant weed biotype will progressively increase until reaching a noticeable level at which an important portion of the weed population is no longer controlled by the herbicide.

Mechanisms of Herbicide Resistance

Several mechanisms of resistance to herbicides have been identified in various weed species. Weeds may evolve resistance to herbicides through **target-site resistance**, which is a structural change of the location, usually an enzyme, where the herbicide active ingredient binds and interferes with physiological processes by inhibiting enzyme activity. Target-site resistance can also be caused by a higher level of enzyme expression in resistant plants (i.e. Palmer amaranth resistance to glyphosate). **Non-target-site resistance** is another mechanism through which plants can develop resistance to herbicides without involving the herbicide active site in the plant. This includes metabolic activity that can enhance the detoxification of herbicide active ingredients, reduction of herbicide absorption or translocation to prevent the active ingredient from reaching its target-site, or sequestration of the active ingredient within an inactive cellular site where it exerts no effect. The management of non-target-site resistance is often more challenging than for target-site resistance because the resistance mechanisms involved in non-target-site resistance may be the expression of natural enhanced tolerance to environmental stresses.

Types of Herbicide Resistance

- **Cross resistance** occurs when a weed develops one resistance mechanism to herbicides from different chemical family that act at the same site of action. For example, a single point mutation in the enzyme acetolactate synthase (ALS) of common ragweed may provide resistance to Classic, a sulfonylurea, and FirstRate, a triazolopyrimidine, both herbicides having the same mechanism of action and belonging to herbicide group 2 (Figure 1).

Figure 1. Example of cross-resistance in common ragweed. Resistant plants are shown in red, susceptible plants in green. (Source: Weed Science Society of America)

- **Multiple resistance** refers to a weed that is resistant to several herbicides with different mechanisms of action. This type of resistance may be the result of two or more different resistance mechanisms within the same plant. For example, imagine that a grower applies FirstRate, an ALS-inhibitor herbicide (group 1), to control common ragweed (Figure 2). The repeated use of FirstRate unintentionally selects for an ALS resistant biotype (shown in black) which will progressively become predominant in the common ragweed population and result in a lack of acceptable ragweed control. The grower switches now to Roundup, an EPSP synthase inhibitor (group 9), and uses it for several continuous years. Roundup will then select for plants resistant to group 9 herbicides within a population that is already resistant to group 1. Ultimately, the common ragweed population will consist of plants resistant to both group 1 and group 9 herbicides, called multiple-herbicide resistant weeds.

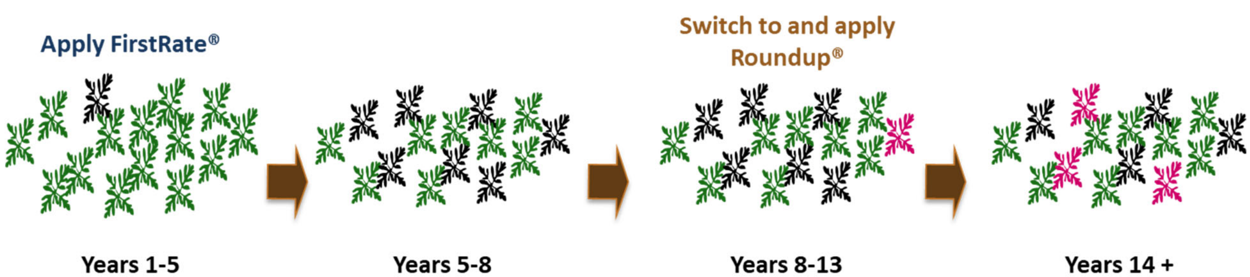

Figure 2. Example of multiple-resistance in common ragweed (Source: Weed Science Society of America)

Factors Affecting Resistance Development

Herbicide chemistry and its behavior in the soil or plant play an important role in the development of herbicide resistance. Herbicides that provide high level of weed control eliminate a great portion of herbicide-susceptible weeds. Since only herbicide-resistant plants will survive and reproduce, resistance is more likely to develop in weeds that are highly susceptible to a specific herbicide.

Herbicides that degrade slowly will place a greater selection pressure because weeds are exposed to the herbicide for a longer period of time. Susceptible seedlings that emerge after the use of herbicide with no or short residual activity will survive, reproduce, and replenish the soil seedbank with herbicide-susceptible seeds. However, susceptible seedlings that emerge after the use of a long-residual herbicide will still be exposed to that herbicide, and only resistant biotypes will survive and reproduce. Herbicides that target a single mechanism of action will more likely favor the emergence and spread of herbicide-resistant weeds than those that interfere with multiple processes in the plant. For example, ALS-inhibitor herbicides (Group 2) specifically target the acetolactate synthase. Any structural change to this enzyme can confer resistance to the different chemical families of ALS inhibitors. On the other hand, chloroacetamide herbicides (Group 15) interact with several enzymes involved in the biosynthesis of long-chain fatty acids. Targeting multiple mechanisms of action may explain why resistance to chloroacetamide herbicides is relatively rare with only five known cases of resistant weeds. However, resistance to ALS inhibitors has been confirmed for 160 species worldwide.

Biology and genetics also are important factors in herbicide resistance development. The frequency of resistance in a weed population prior to herbicide application determines how long it takes for herbicide resistance to evolve. Resistance will spread faster with higher resistance frequencies. A 1:100,000 ration of resistant weeds to total weeds will cause faster spread than a 1:10,000,000 ratio. Also, weeds with greater genetic diversity have greater chance of harboring resistance genes to a specific herbicide. For example, weeds belonging to the *Amaranthus* genus (or pigweeds) have considerable genetic diversity and some species have developed resistance to six herbicide mechanisms of action. Cross pollination and large seed production increase the risk of herbicide resistance dispersion. For example, Palmer amaranth male and female flowers are on separate plants, making cross pollination necessary for the production of seeds. Even plants that are 1,000 feet apart can transfer resistance to glyphosate from one to the other through pollen dissemination. Palmer amaranth averages 500,000 seeds produced per plant when there is no competition, allowing quick spread of glyphosate resistance.

Weed population size also contributes to the onset of herbicide resistance. The greater the number of plants exposed to herbicide, the higher the risk of increased resistance genes frequency and resistance development. Preventing large weed populations and weed soil seedbank replenishment is a key component in herbicide-resistance management.

Key Points

- Overuse of a single herbicide mode of action may lead to the proliferation of individual weeds that can survive its labelled rate which otherwise is lethal on susceptible plants.
- Resistance can be caused by structural modification of the herbicide target within the plant (target-site) or by other metabolic or exclusion mechanisms not related to the target (non-target-site).
- Resistance results in the dominance of one weed species and the exclusion of other species.
- Environmental factors and human-related activities can help resistant weeds spread over large distances.
- Wise use of herbicides, weed management diversification, and early detection of resistant weeds are key strategies in preventing the development and spread of herbicide resistance.

Source
Heap I (2022) The International Survey of Herbicide-resistant Weeds. htpp://www.weedscience.org. Accessed: December 20, 2022

DISTRIBUTION AND IDENTIFICATION OF HERBICIDE RESISTANT (HR) WEEDS

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Herbicide resistance is defined by the Weed Science Society of America (WSSA) as ''the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type." A less formal way of describing it is "we used to be able to control this plant with this rate of herbicide, and now we can't." Herbicide resistance in weedy species is the result of adaptive evolution in response to repeated applications of an herbicide over space and time (i.e. selection pressure). Plant biotypes within a weed population that possess naturally occurring mutations that facilitate survival and seed set following an herbicide treatment will become more dominant over time as susceptible individuals are controlled.

Herbicide resistance is a global phenomenon. As of October 2022, the International Herbicide-Resistant Weed Database (IHRWD) (www.weedscience.org) indicates that there are currently 514 unique cases of herbicide resistant weeds, worldwide. Resistance has been reported in 267 weed species (154 dicots and 113 monocots). Weeds have evolved 165 different herbicides across 21 sites of action. The United States leads the world with respect to herbicide resistant weeds (128). The greatest numbers of unique cases have been confirmed in wheat, corn, rice, and soybean (>200), although specialty crops are not immune; the IHRWD documents 59 reports of resistance in vegetables worldwide with 16 cases occurring in the United States and 7 occurring in Canada. In orchard and vine systems, more than 20 cases of resistance have been documented. With respect to WSSA classes, the greatest number of resistance cases are to the WSSA 2 herbicides (ALS inhibitors), followed by WSSA 5 (103, photosystem II inhibitors), WSSA 9 (52, glyphosate), WSSA 1 (1, ACCase inhibitors), and WSSA 4 (41, synthetic auxins).

Important resistant species in the Northeastern United States include Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus*) tuberculatus, two very tall and fast-growing, dioecious pigweed species, as well as smooth pigweed (*Amaranthus hybridus*), Powell amaranth (*Amaranthus powellii*), and livid/purple amaranth (*Amaranthus blitum*) For more information about pigweed identification, please see: https://cals.cornell.edu/weed-science/weed-identification/pigweed-identification. Other species of importance include horseweed (*Conyza canadensis*) (https://blogs.cornell.edu/weedid/field-crops/horseweed/), lambsquarters (*Chenopodium album*) (https://blogs.cornell.edu/weedid/common-lambsquarters/), common ragweed, (*Ambrosia artemisiifolia*) (https://mdc.mo.gov/discover-nature/field-guide/common-ragweed), ryegrass species (*Lolium spp.*) (https://extension.psu.edu/ryegrass), and giant foxtail (*Setaria faberi*) (https://www.canr.msu.edu/weeds/extension/giant-foxtail). See Virginia Tech's webpage for an excellent online weed identification resource (https://weedid.cals.vt.edu/).

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 Shamokin, 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. In New York, Lynn's research is multifaceted. One area of focus includes documenting glyphosate resistance and resistance to the ALS-inhibiting chemistries in Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*); it also includes describing resistance to paraquat in horseweed (*Erigeron canadensis*). Other weed species-herbicide combinations of concern and investigation include common lambsquarters (*Chenopodium album*) /bentazon, Powell amaranth (*Amaranthus powellii*)/PPO-inhibiting herbicides, and common ragweed (*Ambrosia artemisiifolia*)/clopyralid.

Session 18

New Technologies for NJ Agriculture

Session Chair:
Rick VanVranken

NO ARTICLES SUBMITTED

Workshop I

Produce Safety Alliance Training

Session Chairs:
Wesley Kline,
Meredith Melendez,
and
Jennifer Matthews

Produce Safety Rule Grower Training

Wesley Kline[1], Meredith Melendez[2] and Jennifer Matthews[3]

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The Food Safety Modernization Act (FSMA) was signed into law January 2011. The final rule was published November 2015 and went into effect in January 2018. This is the biggest change to food safety that directly impacts fresh fruit and vegetable growers in over 70 years. However, growers with produce sales of less than $25,000 are not covered under this rule. If the operation produces fresh fruits and vegetables, this Act applies except if the produce is commercially processed, consumed on the farm or meets the qualified exemption.

If all food, including animal feed and farm stand products, sold from the farm is less than $500,000 averaged over the last three years adjusted for inflation based on the most recent baseline values found at https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-inflation-adjusted-cut-offs, goes directly to an end user (restaurant, farm market, roadside stand, supermarket, etc.) and it is sold within 275 miles or within the same state where it is grown then the operation meets the requirement for the qualified exemption. The operation must have receipts or other documents to show they meet this criterion, but there is no specific record which means it could be receipts, sale figures for CSA members, IRS schedule F, etc. There are requirements for signage or labeling if qualified exempt.

Growers should be aware that a buyer may still ask for the operation to meet all the requirements for FSMA or to have a third-party food safety audit. The difference between FSMA and an audit is that FSMA is government regulation and inspection based while a third-party audit is voluntary that may be required by buyers.

Produce Safety Training:
The Produce Safety Alliance Grower Training Course is one way to satisfy the FSMA Produce Safety Rule requirement outlined in § 112.22(c) that requires '*At least one supervisor or responsible party for your farm must have successfully completed food safety training at least equivalent to that received under the standardized curriculum recognized as adequate by the Food and Drug Administration'.* This is the only training recognized by the FDA at this time! And remember if you had an employee that went

through the training but is no longer at your farm then someone else must take the training.

Fruit and vegetables growers and others interested in learning about produce safety, the Food Safety Modernization Act (FSMA) Produce Safety Rule, Good Agricultural Practices (GAPs) and co-management of natural resources and food safety should also attend this training.

What to Expect at the PSA Grower Training Course?
This is a seven-hour course to cover these seven modules:

- Introduction to Produce Safety
- Worker Health, Hygiene, and Training
- Soil Amendments
- Wildlife, Domesticated Animals, and Land Use
- Agricultural Water (Part I: Production Water; Part II: Postharvest Water) and proposed changes to the regulations
- Postharvest Handling and Sanitation
- How to Develop a Farm Food Safety Plan

In addition to learning about produce safety best practices, parts of the FSMA Produce Safety Rule requirements are outlined within each module and are included in the grower manual provided. There is time for questions and discussion, so participants are encouraged to share their experiences and produce safety questions.

Benefits of Attending the Course
The course provides a foundation of Good Agricultural Practices (GAPs) and co-management information, FSMA Produce Safety Rule requirements, and details on how to develop a farm food safety plan. Individuals who participate in this course are expected to gain a basic understanding of:

- Microorganisms relevant to produce safety and where they may be found
- How to identify microbial risks, practices that reduce risks, and how to begin implementing produce safety practices on the farm
- Parts of a farm food safety plan and how to begin writing one
- Requirements in the FSMA Produce Safety Rule and how to meet them

After attending the entire course, participants will be eligible to receive a certificate from the Association of Food and Drug Officials (AFDO) that verifies they have completed the training course. To receive an AFDO certificate, a participant must be present for the entire training course and submit the appropriate paperwork to the trainers at the end of the course.

On-Farm Readiness Review:
As a follow-up to the produce safety training course, farm walkthroughs are available to review farming operations. An On-Farm Readiness Review manual has been developed

to help simplify the Produce Rule for growers. This On-Farm Readiness Review (OFRR) is intended to be used by produce growers to help them prepare for farm inspections conducted under the Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR) and for OFRR reviewers to conduct on-farm assessments. The manual is intended to be adaptable to farms producing a wide range of covered commodities, using diverse production practices, and adaptable to a wide range of geographical production regions using unique growing and harvesting practices. The walkthrough team consists of someone from Cooperative Extension and NJDA.

The purposes of the OFRR process and the farm visits are to:

- Prepare growers for implementation of the FSMA PSR
- Help OFRR reviewers better understand how the PSR gets translated on the farm
- Provide a conversational approach to help growers assess their readiness for implementation of the FSMA PSR
- Provide the tools to help assess how prepared an individual farm is to implement the rule

There are numerous reasons why a grower should undertake an OFRR:

- It is voluntary, free and confidential
- It will help them align what they are doing with what is required in the rule
- It provides a personalized discussion about their farm's food safety activities
- Notes taken by the farmer remain the property of the farmer
- It will improve the farmer's readiness for a PSR inspection

The authors worked under the guiding principle that any farm inspection process should include "education before regulation." The hope, therefore, is that growers and extension and regulatory staff will use the manual to build their knowledge about the PSR and learn the most effective and consistent ways to apply that knowledge on the farm during production and inspection. For produce growers, the manual provides a practical guide for assessing their on-farm food safety practices against the regulatory provisions of the PSR. Farmers are required to also complete PSA Grower Training or equivalent prior to having an OFRR, to maximize the value of that review. Exempt farms may choose to receive a full readiness review as an educational opportunity.
For extension and regulatory staff, the manual provides another resource to help understand the diversity and complexity of farming practices, equipment, and procedures used in the production of fruits and vegetables. The manual helps to identify critical food safety practices that need immediate attention and those that may be addressed in the future. It is meant to be a functional tool that can be used over time to assess practices and compliance, as farming operations or commodities change.

The manual is intended to be a useful and workable tool for growers, extension and inspection staff to improve food safety practices at the farm level. Every person stepping onto a farm, regardless of their role, bears responsibility to help ensure that the best food safety practices are understood and used when growing produce. To sign up for a Readiness Review email Charlotte Muetter at chalotte.muetter@ag.nj.gov.

<u>Workshop II</u>

Discovering Resilience: Farm Law Workshop

<u>Session Chairs:</u>
William Hlubik
and
Brendon Pearsall

NO ARTICLES SUBMITTED

Workshop III

Farm Taxes, Recordkeeping, Farm Financial Management and Best Management Practices

Session Chair:
Robin Brumfield

NO ARTICLES SUBMITTED