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RUTGERS New Jersey Agricultural Experiment Station

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Session Organizers

Tuesday, February 6
Morning Sessions

High Tunnels – A.J. Both, Extension Specialist, Rutgers Cooperative Extension

Direct Marketing/Agritourism –Bill Hlubik, Agricultural Agent, Rutgers Cooperative Extension Middlesex County

Vine Crops – Michelle Infante-Casella, Agricultural Agent, Rutgers Cooperative Extension Gloucester County

Farm Brewery Crops – Bill Bamka, Agricultural Agent, Rutgers Cooperative Extension Burlington County

Gazing into the Crystal Ball – New Technologies in Ag – Rick VanVranken, Agricultural Agent, Rutgers Cooperative Extension Atlantic County

Tuesday, February 6
Afternoon Sessions

Soil Health Management – Michelle Infante-Casella, Agricultural Agent, Rutgers Cooperative Extension Gloucester County

Ethnic/Specialty Crops – Bill Sciarappa, Agricultural Agent, Rutgers Cooperative Extension Monmouth County

Tomato – Tom Orton, Professor of Vegetable Breeding, Rutgers University

Farm Brewery Crops – Steve Komar, Agricultural Agent, Rutgers Cooperative Extension Sussex County

Post-Harvest – Wesley Kline, Agricultural Agent, Rutgers Cooperative Extension Cumberland County

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Small Fruit/Strawberry – Peter Nitzsche, Agricultural Agent, Rutgers Cooperative Extension Morris County

Farm Equipment/Pesticide Safety – Ray Samulis, Agricultural Agent, Rutgers Cooperative Extension Burlington County

IPM Issues – Joe Ingerson-Mahar/Kris Holmstrom, Vegetable IPM Coordinator, Rutgers Cooperative Extension/, Rutgers Vegetable IPM Program

Wine Grapes – Hemant Gohil, Agricultural Agents, Rutgers Cooperative Extension Gloucester County

Peppers – Andy Wyenandt, Extension Specialist in Vegetable Plant Pathology, Rutgers Cooperative Extension

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Food Safety – Meredith Melendez, Agricultural Agent, Rutgers Cooperative Extension Mercer County

Alternative Crops – Jenny Carleo, Agricultural Agent, Rutgers Cooperative Extension Cape May County

Farm Viability Programs – Brian Schilling, Rutgers Cooperative Extension Specialist in Ag Policy

Organic Agriculture – Joe Heckman, Rutgers Cooperative Extension Specialist in Soil Fertility

Blueberries – Gary Pavlis, Agricultural Agent, Rutgers Cooperative Extension Atlantic County

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High Tunnels

HIGH TUNNEL CROP PRODUCTION IN DELAWARE

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Use of unheated protected structures to grow vegetables and fruits in Delaware on a large scale began with asian producers using free standing straight walled wood frames covered with poly. These structures did not have roll-up sidewalls but did have the ability to open the end walls. A wide range of crops were grown in these structures including asian melons, asian greens, eggplants, edible gourds, asian cucumbers and other crops for the asian markets in New York.

Currently, the largest high tunnel production in acreage in Delaware is still with asian vegetables; however, the structures have largely changed to free standing (single) metal frames with roll up sides or multi-bay tunnels. One Delaware producer has over 10 acres of high tunnels in asian vegetable production.

Prior to the NRCS cost share program with high tunnels, unheated protected vegetable production on Delmarva (other than asian vegetable producers) was limited to a few early adopters. Most of these growers converted cold frames by adding roll up sides and concentrated on producing a wide range of early vegetables for their own markets. With the NRCS cost share, dozens of high tunnels were constructed across the state, with the majority being small growers (less than 10 acres) and a significant percentage growing organically. These tunnels ranged from 48’ to 98’ in length and 20’-30’ in width with straight side walls and roll up sides.

A small number of multi-bay, European style tunnels of ½ acre or larger have also been constructed by larger vegetable and fruit growers. The most popular crop in these multi-bay tunnels is tomatoes. However, other crops such as strawberries and brambles have also been grown in these large tunnels.

Ranking of vegetables and fruits being grown in high tunnels on Delmarva

1) Leafy greens (including asian greens)
2) Tomatoes
3) Mixed vegetables (often organic)
4) Cucumbers
5) Asian melons
6) Strawberries
7) Eggplants
8) Cut flowers
9) Cherries

Example High Tunnel Extension and Research Projects in Delaware

Delaware State University High Tunnel Demonstration Area

Our sister land-grant university has taken the lead on doing education on high tunnel production for small growers. The have developed a demonstration area with 6 different high tunnel designs for growers to visit with a wide range of crops grown for season extension to learn from

Tomato Planting Dates for Fall Production

An experiment was conducted in a multi-bay high tunnel at Fifer Orchards on the best summer transplanting date for fall tomato production with 3 planting dates and 3 varieties.

Results:

The July 15 planting yielded the best in the trial and I would recommend a mid July planting in the tunnel for fall harvest. BHN 589 was the variety that did the best. BHN 589 has some heat tolerance and can stand the early tunnel heat conditions in August better than the others. Tonnage of the BHN 589 was very good. If selling by the quart at 6 tomatoes per quart and $3.00 retail per quart with 80% number ones, per acre gross returns with mid-July planted BHN 589 would be around $51,000 based on 6' centers. If selling by the pound at $1.00 per pound, gross per acre revenue would be $59,000. Selling wholesale at $8.00 per 25 lb box, gross per acre revenue for mid-July planted BHN 589 would be around $19,000.

All varieties

Planting	Total #	#/a	Total wt	Ton/a	
15-Jul	185	127835	102.9	35.6	a
25-Jul	65	44915	39.7	13.7	b
5-Aug	10	6910	6.4	2.2	c

BHN 589

Planting	Total #	#/a	Total wt	Ton/a	
15-Jul	193	133363	107.6	37.2	a
25-Jul	91	62881	52.9	18.3	b
5-Aug	10	6910	6.0	2.1	c

High Tunnel Small Fruits

Working with Fifer orchards in multi-bay high tunnel, a number of demonstrations on growing small fruits in high tunnels were conducted.

Primocane raspberries: Fall fruited red rasperried were planted in one bay of the high tunnel. Heat accumulation affected yields and quality in late summer and did not improve until the end of September. This proved not to be a profitable crop.

Early strawberry production: September planted plasticulture strawberries were grown in one bay of the high tunnel. Strawberries came into production 10-20 days earlier than outside. This did not result in increased profit in the retail market because consumers we not prepared to buy strawberries that early and it did not coincide with asparagus season.

Day neutral strawberry production for extended harvest: Albion strawberries were fall planted in plasticulture in one bay of the high tunnel. Spring production began 8 days before outside production and quality was excellent. In addition, production continued into July. However, profits were less than tomatoes grown in the multi-bay tunnel

Shade Cloth Use in High Tunnels

Working with a small organic grower, white shade cloth was used to cover over a high tunnel to extend production of lettuce into the summer. Temperatures were 10-20 degrees cooler in the white shade cloth covered area and the growers were able to maintain lettuce quality throughout the hot summer months (July and early August).

High Tunnel Dwarf Sweet Cherries

Working with T.S. Smith and sons, three experiments with dwarf cherries in high tunnels were conducted including variety trials, pollenizer trials, and pruning system trials.

There is very limited production of sweet cherries in Delaware. This is due to problems with bird damage and well as cherry cracking during ripening with heavy rains. Multi-bay European style high tunnels have been shown in nearby states to be effective in managing bird damage and rain damage using dwarf cherries. We were able to evaluate a first cropping year of dwarf sweet cherry production in a multi-bay high tunnel using the experimental block already planted under Delaware conditions.

Working with the University of Delaware, our dwarf sweet cherry block is planted in a randomized experimental design allowing for the evaluation varieties and pollinizers. The first bay of the tunnel was planted in Regina with Hudson and Black Gold as pollinizers. The goal was to evaluate pollinizer effectiveness. In 2015 Regina did not achieve full yield. Yield did not differ by pollinizer but trees closest to pollinizers had higher yields.

The second bay of the high tunnel was planted in two cross pollinating varieties, Attica and Summit. This is a yield by training system study. Training systems were 1) controlled central leader and 2) fruiting wall. Both varieties did not achieve full yield as they were not yet fully mature. The central leader system yielded better than the fruiting wall.

The third bay of the high tunnel was planted with Black Pearl with Lapins and White Gold as pollinizers. This is a training system by pollinzer study. Again, both pollinzers were effective but trees closer to the pollinizers were more productive and the central leader system was more productive than the fruiting wall. Black Pearl was the most productive of all the cherries planted in the 3 bays. Trees were more mature and near full production. Black Pearl was hand picked. A total of 359 lbs of cherries were produced (5.15 lbs/tree) from May 29 through June 11. The combined yield of Attika, Summit, and Regina was 221 lbs. White gold yielded 25 lbs. Black pearl appears to be a very suitable early variety for the area.

Consumer taste tests of cherries were done at Farmers Markets. The highest rated were Black Pearl and Regina (rating of 4 on a 1-5 scale). Attica was rated 3 on 1-5 scale and Summit was rated a 2. White cherries were rated 3.

HIGH TUNNELS IN PENNSYLVANIA – WHAT ARE WE LEARNING?

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The high tunnels at Penn State's High Tunnel Research and Extension facility have been in use for about 20 years, and some growers in PA have been using tunnels nearly as long or longer. While the advantages of high tunnel use were apparent right away (improved yields and better fruit quality), over time there were other questions that crept in as practices changed. Some of the more common ones appears below.

What Can One Do to Manage Soluble Salts Buildup?
Fertilizers, compost, and irrigation water can all be sources of salts in the soil. If tunnels that are covered all year long are the type being used, opportunities for salts to be leached from the soil are limited. Further, many growers tend to grow the same crop in a tunnel for several years in a row rather than rotate crops as may more easily be done in field production, and if these crops are "heavy feeders" and also are tolerant of salts (tomatoes, for example), relatively high rates of fertilizer may be applied over several years. A final consideration is water quality – in tunnels, the irrigation source takes on added importance, since it is the sole water source. If the irrigation source is high in calcium or magnesium bicarbonates, pH may creep up and these elements may accumulate in the soil. In addition, there may be increased evaporation from the soil surface in tunnels due to the drier environment, especially if no plastic mulch is used. Generally an issue only becomes apparent if a less tolerant crop is subsequently grown and after the ground was worked, incorporating the salts that accumulated on the surface into the root zone. What are some solutions to these issues?

First, the soil tests done should include one for salt levels. If using inorganic fertilizer sources, look for ones that have a low salt index and if using composts, especially ones containing manures, make sure they are aged to allow salts to leach from them. Consider using plastic mulch or an inorganic mulch to minimize evaporation (be aware that this may increase vole and mice presence), and keep crops irrigated to avoid drought stress. When it is time for plastic to be replaced, remove it in the fall to allow time for rain and melting snow to leach salts through the soil – this will typically reduce salt levels by about half. After plastic has been replaced, grow the least salt-tolerant crops ahead of those that are more tolerant. Lastly, if a crop is showing salt damage and plastic-mulched raised beds were used, it is possible to move salts into the row middles by irrigating very heavily, letting the soil dry, and repeating the process. In our tunnels, this required about 5 8-hr cycles of watering, but we were able to rescue a strawberry crop.

Do You Really Have to Rotate Crops?
In tunnels, it is tempting to keep growing the same most profitable crops in the same space over and over. Some of the diseases or pests that are common problems in the field seem to develop more slowly in tunnels, and since space is limited, growers often tend to grow the same crops for longer periods of time in the tunnels. Some growers in PA are beginning to have problems where tomatoes have been present for a number of years, including dagger nematodes resulting in tomato ringspot virus, and timber rot.

So, it still makes sense to rotate, possibly by using multiple tunnels, or using moveable tunnels. An interesting and relatively new area of research is that of anaerobic soil disinfestation (ASD) where practices are employed that increase the population of beneficial soil organisms while decreasing those of harmful ones. For some diseases, biocontrols also have considerable potential.

What about Growing in Containers?
In our current research, because we wanted to compare effects of plastics on different tunnels (and not soil nutrient differences in the tunnels), we switched to growing strawberries and raspberries in containers. It was easier than we expected, at least during the growing season, once we found the right media to use. The media needed to have a good combination of soil moisture holding capacity and drainage. For strawberries, a 2:1 mixture of peat to coarse perlite worked best. Raspberries aren't quite as fussy as strawberries, but this mixture also worked really well for them, also.

Container size and depth was also important, as this "buys" some latitude in water holding capacity and drainage. Strawberries did best with containers at least 6 inches deep. Ours were white, since strawberry roots are sensitive to high temperatures.

What is a major problem with perennial plants in containers is how to overwinter them. Raspberry roots are very sensitive to cold temperatures, and are much more exposed to temperature fluctuations when in pots. This meant that plants needed to be protected over the winter, so this year we moved into a cellar area of a barn, or a cold room. When we left the containers in the tunnels last year, similar to what might be done in the nursery industry, we found that voles also love the loose media in pots, and as it turns out, apparently raspberry roots are tasty, especially if the variety is 'Polka'. That meant a lot of effort in vole control, which was never enough.

Does Type of Plastic Cover Make a Difference?
A USDA-NIFA Specialty Crops Initiative Project "Optimizing Protected Culture Environments for Berry Crops", led by Michigan State University and involving research and extension personnel at 7 Universities plus the USDA, along with grower and industry advisors, has allowed us to focus on this question – some of the background on the project was discussed at last year's meeting, and appears in last year's proceedings articles. For this project, plastics with specific characteristics related to light transmission were chosen and tested.

Since raspberries are a perennial crop, it is still too early to reach conclusions about yield. However, what has been apparent is that effects other than those on yields may be the most important ones. Behavior of certain insects, particularly Japanese beetles, was greatly affected. All plastics reduced numbers of beetles feeding on raspberry plants by at least 1/3 to 1/2, with some plastics reducing numbers about 90%. In 2016, spotted wing drosophila adult numbers were also reduced by all plastics compared to no plastic, and more by some plastics than others in 2016 (2017 data is not yet analyzed). However, since just a few SWD adults can result in large numbers of larvae in fruit, none of the plastics provided sufficient control on their own, so the next step is to look at other management strategies that could be used in combination. Research at Michigan State University, for example, documented a large influence of raspberry harvest interval on larval presence in fruit, with SWD numbers being greatly reduced if berries were harvested every day, somewhat reduced with every other day harvest, and much higher when harvest took place every third day.

How important plastics effects are will of course, vary with the crop and the pests affecting the crop, but it is apparent that this is an area where research should be continued. The potential for impacts on how pests are managed, especially for crops that are particularly susceptible to damage from certain pests, is large.

Can We Do Something about Plastic Waste?

One thing that we've learned is that price, and therefore demand for plastics for recycling, varies with many outside factors such as oil prices. A bright spot is that high tunnel and greenhouse plastics are clean, and desirable for recycling material. A plastics company that is involved with our project advisory committee (Delta Plastics, and their recycling arm, Revolution Plastics) has launched a pilot project in the Upper Midwest to improve recycling options. They have indicated an interest in expanding this program to the Northeast.

Still Learning

While tunnels certainly have a lot of potential for increasing yields and providing increased control over environmental conditions, there is plenty to do in learning how to best utilize tunnels and how to maximize their benefits. More work is needed in economics to understand which practices are more profitable, and which ones might not be. In any event, it appears that tunnel use, and the need for improved practices, will only increase over time.

This work is based in part upon research supported by the USDA National Institute of Food and Agriculture, Section 7311 of the Food, Conservation and Energy Act of 2008 (AREERA), Specialty Crops Research Initiative under Agreement 2014-51181-22380.

More information on the project can be found at www.tunnelberries.org . Thanks to the Pennsylvania Vegetable Growers Association for providing funds used towards a matching requirement for the TunnelBerries project.

Direct Marketing/ Agritourism

COMMUNICATING FRESH PRODUCE FOOD SAFETY TO YOUR ADVANTAGE

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Human pathogen outbreaks associated with fresh produce are a reality. Human pathogens can be transferred from one person to another through the surface of produce that is consumed raw. This is most commonly done through the fecal-hand-oral route of contamination. Scientific progress has allowed for greater understanding of the human pathogens that can be found in the farm environment, the spread of these pathogens and the potential for multiple illnesses relating to contaminated produce. Farmers are interested in producing the highest quality fruits and vegetables, and this must include understanding the human pathogen risks on their own farm and the development of risk reeducation measures.

Recent large-scale outbreaks involving human deaths relating to the consumption of fresh produce items received a lot of media attention. The 2006 E. coli outbreak on California spinach impacted the spinach market on the east coast. The outbreak was specific to California spinach from one farm, but the consumer gut reaction was to stop purchasing spinach entirely. This is devastating for farmers nationally, and fluency in food safety risks on your fam and the methods you are using to reduce those risks can bolster consumer trust in your products.

Farms selling produce wholesale are likely more aware of food safety regulations and purchaser demands. Wholesale buyers may communicate with farms that a third-party audit is required in order for them to purchase produce. There are many types of audits available and the buyer of the produce will indicate what they expect from the farm. Farms already completing third party audit inspections will want to advertise this certification on marketing materials and websites to attract new buyers. Most wholesale produce growers will need to comply with the Food Safety Modernization Act Produce Safety Rule. Attendance as an approved FDA training for this regulation will be mandatory, with a timeframe dependent on the size of the operation. Farms achieving compliance with the training requirements and required practices should communicate this to their buyers if not already in communication with them about the regulation.

Direct market producers of produce are more likely to encounter questions from their customers about pesticide residues and GMOs. Continued media attention to large scale produce recalls due to human pathogen contamination increases the public's awareness of issues and will ultimately lead to questions at the farm stand on the topic of human pathogens. Attending an Extension run Good Agricultural Practices training can help farms identify risk areas at the farm, develop risk-reduction practices and allow for a greater comfort level in answering customer questions on the topic.

Understanding commonly used terms relating to food safety on farms is important for developing and communicating your farms food safety practices. This glossary highlights a few definitions, found in the Produce Safety Alliance Grower Training Manual.

Cleaning – Physical removal of dirt (soil) from surfaces which can include the use of clean water and detergent.

Clean break – A break in production where all the food contact surfaces on the production line are cleaned and sanitized with a documented, verified, and validated process.

Composting – A process to produce stabilized compost in which organic material is decomposed by the actions of microorganisms under thermophilic conditions for a designated period of time at a designated temperature, followed by a curing stage under curing conditions.

Corrective actions – Actions taken to correct a problem and identify why it occurred in order to prevent it from happening again.

Cross-contamination – Contamination of one food item with microbial pathogens from another food item, water, surface, or other object.

Detergent – A cleaning agent that contains surfactants that reduce surface tension between food surfaces and dirt (soil) or other debris. Detergents aid in lifting dirt off of surfaces. Detergents are used in the cleaning process before a sanitizer.

Farm food safety plan – A written document that outlines the farm's food safety practices and may include recordkeeping logs, Standard Operating Procedures (SOPs), and other supporting documents.

Food contact surfaces – The surfaces that contact human food and those surfaces from which drainage, or other transfer, into the food or onto surfaces that contact the food ordinarily occurs during the normal course of operations. This includes food contact surfaces of equipment and tools used during harvest, packing and holding.

Good Agricultural Practices (GAPs) – Any agricultural management practice or operational procedures that reduces microbial risks or prevents contamination of fruits and vegetables on the farm or in packing areas.

Microorganisms – Microorganisms means yeasts, molds, bacteria, viruses, protozoa, and microscopic parasites and includes species having public health significance. The term ‘undesirable microorganisms’ includes those microorganisms that are of public health significance, that subject food to decomposition, that indicate that food is contaminated with filth, or that otherwise may cause food to be adulterated.

No-harvest buffer zone – A defined distance around an identified risk from which produce should not be harvested. No-harvest buffer zones can be established around fecal contamination or around areas of significant animal intrusion to minimize the risk of harvesting produce that has been contaminated.

Postharvest water – Water that meets the definition of agricultural water and is used during and after harvest of produce.

Risk assessment – A process to identify potential hazards on a farm and/or in a packinghouse as well as the likelihood the hazards will impact the safety of fruits and vegetables.

Sanitize – To adequately treat cleaned surfaces by a process that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the produce or its safety for the consumer.

Sanitizer – A substance that reduces the amount of microorganisms to acceptable levels, typically for use on food contact surfaces. Sanitizers are generally considered to be part of a broader group of substances called antimicrobial pesticides. The antimicrobial product label will describe approved uses, such as for water or food contact surfaces, as well as approved concentrations or dosages.

Standard Operating Procedures (SOP) – Written description of an activity and how to properly complete the activity. An SOP should specify all the materials needed to complete the activity, the frequency with which the activity is conducted, and how to document the activity. An SOP may also include which employees are responsible for completing the activity and provide corrective actions to mitigate the problems that are likely to happen.

Traceability – The ability to track food produce through the food production and distribution system. In the case of fruits and vegetables, this includes back to the field where it was grown and any subsequent handling, storage, and sale.

Worker – Any person, paid or unpaid, working on a farm that grows or packs fresh fruits and vegetables. This includes growers, farm managers, family members, migrant labor, summer help, and packinghouse employees.

There are many Extension based resources available to help farmers navigate food safety concepts, regulations and audits.

National Good Agricultural Practices Program, Cornell
https://gaps.cornell.edu/

Produce Safety Alliance, Cornell (FSMA Produce Safety Rule, Trainings by state)
https://producesafetyalliance.cornell.edu/

Produce Food Safety Program, University of California, Davis
http://ucfoodsafety.ucdavis.edu/Preharvest/

Rutgers Plant and Pest Advisory, Food Safety
http://plant-pest-advisory.rutgers.edu/category/commercial-ag-updates/food-safety/

BUILDING YOUR FARM MARKETING BRAND & IDENTITY

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Branding is how you define the core of your business to yourself and your customer-base. It is how customers and external audiences see your farms identity through the conveyance of values, purpose, and passions. This presentation covers several parts of a branding guide that can help your farm business establish and/or refine its own identity for marketing purposes. Your brand identity helps to communicate key elements of your farm business to employees and customers, members of the community, and stakeholders.

Base Elements of Your Brand:

- About/History*:* What is your story? Why did you start your farm business?
- *Mission:* What's your why? Why are you in business? What products or services will be marketed and their purpose;
- *Personality:* If your brand was a person, how would it communicate? What are your values? *Customers are more likely to purchase from a brand if it's 'personality' is similar to their own, or one they admire.*

To succeed in branding, understanding the needs of your customers is critical. This presentation will also explore other external factors to consider when building your farm marketing brand, such as:

- *Defining target customers;*
- *Messaging & unique selling points;*
- *Marketing/sales opportunities.*

Building your farm brand also creates loyal, educated employees. Allow your brand to help employees understand the purpose and values business. After all, your employees are part of your brand personality. Building a brand for your farm operation will add great value and contribute to overall farm marketing success.

Vine Crops

IDENTIFYING INSECT PESTS IN CUCURBIT CROPS

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Below is a description of major pests that feed on cucurbit crops in New Jersey. For information on controlling these pests see crop sections of the 2018 Mid-Atlantic Commercial Vegetable Production Recommendations. Photos of each pest will be shown in the presentation.

Seedcorn Maggot

Damage:
The seedcorn maggot (*Delia platura*) feeds on decomposing plant debris and organic matter in the soil, including seeds before or after germination. In most cases, seedcorn maggot may be a problem in early season plantings seeds are slow to germinate during cool wet periods in spring. Seed or seedling loss will occur if maggots feed on the seed or seedling stems. If only partially damaged, seeds will germinate, but may be leafless or show signs of feeding damage on leaf edges. These damaged plants rarely produce a crop. Missing plants can be reseeded, however may mature 1-2 weeks after the first planted seeds.

Appearance and Life Cycle:
Seedcorn maggots are small white legless larvae that are 1/4 inch long. Seedcorn adults are a dark gray flies that are much smaller and thinner than a housefly. They overwinter as protected larvae in soil and flies emerge in April or May. The flies are attracted to soils high in organic matter to lay eggs. They also will favor soil that has been recently tilled to lay eggs. The first generation is the one that does damage in spring. However, seedcorn maggot can have 3 generations per year, but seeds germinate more quickly in warmer soils and this pest is generally not of concern in late spring, summer and fall.

Cucumber Beetles

There are a few different types of cucumber beetle that will feed on cucurbits.

• The **striped cucumber beetle** (*Acalymma vittatum*) is the main pest of cucurbits and controlling this pest is extremely important due to the damage and disease spreading capability of this insect. It is especially important to control in the seedling stage.

• The **spotted cucumber beetle** (*Diabrotica undecimpunctata howardi*) is similar to striped cucumber beetle in importance to control. However, high numbers of

the spotted cucumber beetle generally do not occur until mid-summer. Another name for the spotted cucumber beetle is the southern corn rootworm. It too can cause significant damage and spread diseases.

<u>Damage</u>:
Adults and larvae in soil can cause seedling loss and loss of plants throughout many stages of growth through these means:
1) Adults transmit bacterial wilt disease that will collapse entire plants
2) Adults feed on leaves and stems in the spring, and later feed on blossoms and on fruit, especially the underside of small fruit causing scaring and making the fruit unmarketable
3) Larvae feed on roots, causing wilting and ultimately plant death
4) Larvae feed on rinds of fruit where fruit are in contact with soil.

Damage by adult beetles is more serious than damage by larvae. Plants are most vulnerable immediately after they are transplanted, or when direct seeded crops emerge from the soil. Groups of adults can be found together on certain plants due to an aggregation pheromone that will attract beetles. When soils are moist, egg and larvae survival is more successful and beetle populations will increase more rapidly. Additionally, larval feeding is more prevalent in moist soils.

<u>Appearance</u>:
Adults are black and yellow beetles, 1/4 inch long. Larvae are white, 1/3 inch long when fully grown. The striped cucumber beetle has a black belly and sharply distinct stripes that extend to the tip of the wing covers. The spotted cucumber beetle is greenish yellow with black spots and is slightly larger than the striped cucumber beetle.

<u>Life Cycle</u>:
Cucumber beetles overwinter as adults in debris in fields, hedgerows, and woodlands, usually within 1 mile of where they were born. In the spring, adults feed on wild plants until the first cucurbits emerge. Beetles will first be found in cucurbit fields nearest to wooded areas. Eggs of striped cucumber beetles are laid at the plant base or in cracks in the soil; larvae feed in soil for 2 to 6 weeks, then pupate into adults in soil. There are usually two generations per year. Both the striped and spotted beetles may overwinter in New Jersey, but the striped beetle is generally a more serious pest because it survives winters much better than the spotted beetle. After a mild winter, both may be found in spring.

Aphids

Damage:
Aphids feed by sucking sap from plant leaves. Damage due to their feeding activity includes speckled leaves, curled leaves, stunted or distorted vines, lower yields, poorly developed fruit and loss of melon flavor. Significant damage from aphids is caused by their transmission of several virus diseases such as zucchini yellow mosaic virus, watermelon mosaic virus, cucumber mosaic virus, and papaya ringspot virus. Aphid excrement is also a medium for sooty mold that may appear on leaves as a dark coating. Additionally, ants may feed on aphid excrement. Therefore, seeing ants on a plant may be an indicator of aphids. It is best to control aphids at first sighting before populations explode.

Appearance:
Aphids are soft-bodied insects that are 1/16 to 1/8 inch long. Under a hand lens a characteristic pair of cornicles (‘tail-pipes’) can be seen projecting from the back end of the abdomen. Adults may be either winged or wingless. Immature aphids are called nymphs and look like wingless adults but are much smaller.

- The **melon aphid** (*Aphis gossypii*) is green to greenish-black, or yellowish, with white legs, black feet, and black cornicles. The winged forms are shiny, while the wingless forms are dull due to a slight waxy powder. They feed on the undersides of leaves and spread to terminal shoots. Melon aphids, like most aphids are more abundant on the lower part of the plant where they are protected. Wingless forms are usually 0.9 to 1.8 mm in length.

- The **green peach aphid** (*Myzus persicae*) can be various colors from light green to translucent to pink. Its cornicles are the same shade as the body. The body is egg-shaped, with the width of the abdomen about the same from the thorax to the bases of the cornicles, the cauda (tail) is short, and cornicles are slightly swollen at the tip. The winged form has a dark patch in the middle of the back. Wingless forms are usually 1.2 to 2.3 mm in length.

Life cycle:
Aphids have complex life cycles. Most species overwinter as eggs: green peach aphid eggs are found on peach trees or trees related to peaches, potato aphid eggs overwinter on roses, and melon aphid eggs on live-forever (*Sedum purpureum*) plants. Once eggs hatch in the spring, the aphids go through many generations without males and females give birth to live young rather than laying eggs. In the fall, males are produced and they go through the sexual part of their life cycle before eggs are laid on winter plant hosts. There can be many generations per year depending on weather conditions.

Squash Bug

Damage:
The adults and nymphs of the squash bug feed by sucking sap from leaves and stems. After feeding occurs plants will wilt. After wilting patches of leaf tissue to turn black and dry out. Young plants may die, or if they survive plants may not develop fruit. The squash bug usually does not attack melons or cucumbers, but can be a serious pest of winter and summer squash, gourds, and pumpkins.

Appearance:
Adults of the squash bug (*Anasa tristis*) are dark brown and 2/3 inch long. Eggs are brown, shiny, oval, and usually in clusters on the underside of leaves where two veins meet. Nymphs are initially green and later turn gray as they mature.

Life Cycle:
The squash bug overwinters as an adult in plant debris at field edges, under structures, in firewood, or other protected places. The squash bug has only one generation per year. They emerge to mate and lay eggs in June. Eggs are laid on the undersides of leaves and hatch after 1 to 2 weeks. Nymphs feed for about one month and generally during the daytime and then hide under soil debris at night.

Squash Vine Borer

Damage:
The squash vine borer (*Melittia cucurbitae*) can be a serious pest of zucchini, other squash and gourds. Larvae bore into the base of stems, causing plants to wilt suddenly and die. It is extremely difficult to control this pest since once it enters the stem, insecticides cannot reach the insect.

Appearance:
Larvae are fat white grubs with brown head and 1 inch long when fully grown. The adult is a wasp-like moth that has a black and orange body, metallic green forewings, transparent hindwings, and hairy black and orange hind legs.

Life Cycle:
This pest overwinters in a cocoon as a full-grown larva in soil. During spring the squash vine borer pupates and emerges as a moth in June. The adult moth flies during the day and lays eggs at the stem base. Eggs take 6 to 15 days to hatch, depending on temperatures. Larvae bore into stem and can feed for about one month. The squash vine borer generally has only one generation per year, but can sometimes have a second generation if hot temperatures persist in fall.

Spider Mites

<u>Damage</u>:
The two-spotted spider mites (*Tetranychus urticae*) suck sap from the undersides of leaves, causing a speckled or bronzed look. Webbing will also be present on undersides of leaves. Two-spotted spider mite feeding can hinder the size, flavor, and sugar content of melons, and can cause leaves to die if populations are in high numbers. Mites will also feed on other cucurbits. Mites may be most damaging when weather is hot and dry since these conditions promote rapid reproduction and growth of mites.

<u>Appearance & life cycle</u>: Adults are 8-legged, 1/60 inch and white bodied with two dark spots. Nymphs are smaller and darker than adults. A new generation of mites can be produced in just 10 days when conditions are favorable. Therefore, many generations occur each year. The adult mites overwinter in ground cover in wooded areas and in plant debris.

Pickleworm

These pests do not overwinter in NJ. The pickleworm lives in more southern states, but adult moths can occasionally migrate to northern areas in late summer or fall. The larva of the pickleworm (*Diaphania nitidalis*) feeds for a period of 2 to 4 weeks. It first feeds on buds and young fruit, also blooms and stems, and later on maturing fruit. On fruit it makes shallow cavities in the rind, or bores through the rind and feeds on the fruit interior. The brown headed larva is initially yellowish white with dark spots. As it grow, the spots disappear and the color becomes yellowish green. The worm is 3/4 inch long when fully grown. The adult moth is yellow and brown with a purplish tinge, with a brush at the tip of the abdomen. Pickleworm moths lay eggs on buds, leaves, stems, or young fruits. It is not very common in New Jersey.

UPDATE ON HERBICIDES AND RESTRICTIONS IN VINE CROPS

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Cucurbits are a very diverse group of vegetable crops that includes in our region melons, watermelon, summer and winter squash, pumpkin, and cucumber. 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 ultimately 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 is crucial for maintaining your crop yield potential. Later, the trailing growth of some cucurbits (cucumber, melons, watermelons…) will provide sufficient shading of the ground for reducing the need for weed management.

Scouting for Weeds

Weeds have generally to 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 may extremely important with regards to chemical weed control. 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 (http://www.cornellpress.cornell.edu/book/) or weed identification websites (http://oak.ppws.vt.edu/~flessner/weedguide/) can be helpful to accurately determine weed species and become familiar with their biology and ecology.

Weed Management before 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 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 cucurbits, 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 period, thus maximizing the number of weeds controlled.

Plant or transplant cucurbits 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 cucurbits for soil applications prior to weed emergence and crop planting. However, some herbicides may only be labeled for specific cucurbit crops. For example, Sandea (halosulfuron) is labeled for use on cantaloupes, honeydew melons, and Crenshaw melons, but **NOT** labeled on muskmelons. Command (clomazone) is labeled for winter squash and processing pumpkins, but **NOT** for jack-o-lantern pumpkins. There are also restrictions on soil-applied preemergence herbicides based on the production system. For example, on cucumbers, Prefar (bensulide) can be soil-applied for preemergence weed control on the row under plastic much or on bare ground as well as between the rows. On the opposite, Treflan (trifluralin) can only be applied between rows as a directed spray after crop emergence when plants have reached the 3 to 4 true leaf stage of growth.

You should **always** refer to the label or the Mid-Atlantic Commercial Vegetable Production Recommendations 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 almost always results in 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. 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 label instructions regarding the use of adjuvants with these herbicides. Sethoxydim will not control annual bluegrass and it varies in its ability to control particular grass species. For effective control of perennial grasses (bermudagrass and johnsongrass), 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. Some carryover can occur under certain conditions, creating a plant back problem. Consult the herbicide label before application.

RECENT WATERMELON RESEARCH IN DELAWARE

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Variety Trials

The 2016 Seedless Watermelon Variety Trial included 35 varieties from ten participating companies. The purpose of this trial was to evaluate seedless watermelon varieties for yield, quality and maturity. Also included were two grafted treatments. The trial was conducted in a grower's field next to the University of Delaware, Carvel Research Center.

The highest yielding varieties in the trial in terms of Marketable Yield were: Maxima, Talca, Premont, 7187, Crunchy Red, Grafted Fascination low population, Road Trip, SV7112WA, Wolverine, and Cut Above. The highest yielding varieties in the trial in terms of fruit/A were: Maxima, Talca, Premont, 7187, Crunchy Red, Grafted Fascination low population, Road Trip, SV7112WA, Wolverine, Cut Above, Unbridled, 7197, Wayfarer, Grafted Fascination, Traveler, ORS 6151, Razorback, and Neptune. Grafted Fascination (using interspecific Cucurbita rootstock) planted at 78% of population of ungrafted Fascination yielded 22% higher. Fruits were heavier and there were significantly more fruits in the second and third harvests compared to ungrafted Fascination. Yields of grafted Fascination planted at the same population as ungrafted Fascination were not statistically different from ungrafted plots.

The 2017 Seedless Watermelon Variety Trial included 33 varieties from 9 participating companies. The purpose of this trial was to evaluate seedless watermelon varieties for yield, quality and maturity. The trial was conducted at the Thurman Adams Research farm, University of Delaware, Carvel Research Center.

Plants were transplanted to the field on May 17, 2017. Due to the late spring, plots were not harvested until August. Fruit were harvested three times. The first harvest was on August 2 and 3 at 77 days after transplanting (DAT), the second harvest was 95 DAT, and the final harvest was in early September at 115 DAT. The weight of each watermelon harvested was recorded individually. Five marketable watermelons from each plot were cut and evaluated for presence of hollow heart and soluble solids levels.

The highest yielding varieties in the trial in terms of marketable pounds per acre were: Crunchy Red, 9651, Turnpike, 9601, Bottle Rocket, Warrior, SV 0241 WA, Fascination, KB 10770, ORS 6278, Kingman and XWT 6009. This high yielding group ranged from 135,220 to 99,230 lbs per acre.

The highest yielding varieties in the trial in terms of fruit per acres were: Crunchy Red, Turnpike, SV 0241 WA, Warrior, Kingman, ORS 6151, and 9601 ranging from 7,836 to 6396 melons per acre.

All varieties produced more than 40% of their yield on the first harvest. The following varieties produced more than 60% of their yield on the first harvest: ORS 6253, SV 3105 WA, ORS 6278, KB 10770, WDL 2413, ORS 6260, Charismatic, ORS 6305, Road Trip Captivation, XWT 6008, ORS 6151, Fascination, Bottle Rocket, Summer Breeze, and 7197. Those varieties with extended harvest (50% or more harvested in the second and third harvest) were Secretariat, Turnpike, and 9601.

Varieties were also sorted according to average fruit in each of four weight classes: 60 count (9.0-13.5 lbs), 45 count (13.6-17.5 lbs), 36 count (17.6-21.4 lbs) and 30 count (>21.5 lbs). In general, fruit weights were above avearage in 2017. Large fruited varieties with average weights over 18 pounds were Bottle Rocket, Maxima, SV 3105 WA, ORS 6278, ORS 6305, Joy Ride, and Road Trip. Medium fruited varieties over 16 pounds included KB 10770, Captivation, Summer Breeze, WDL 2413, Crunchy Red, 7187, ORS 6260, 9601, XWT 6009, 7197, Fascination, Wolverine, Unbridled, Turnpike, Warrior, XWT 6008, SV 0241 WA, and Charismatic.

Those varieties with more that 35% of the melons harvested in the 45 count class included XWT 6008, ORS 6260, Kingman, 7197, ORS 6253, Charismatic, SV 0241 WA, and Secretariat. Varieties with high percentage of small fruited melons (60 count) included ORS 7033 B, Secretariat, ORS 6151, 9651 and Kingman. Varieties with high numbers of 36 count fruit were Captivation, 9601, Road Trip, Unbridled, Charismatic, and Wolverine. Bottle Rocket, SV 3105 WA, ORS 6305, ORS 6278, and Maxima produced over 30% in the 30 count class (very large melons).

Two small fruited "mini" melons, Mini Bee and ORS 7033 B were also tested. They had the highest number of fruits at 8,931 and 9,968 melons per acre respectively. Mini Bee produced over 80% of its melons in the personal or icebox size class from 4 to 9 pounds. ORS 7033 B produced 41% of its melons in the small size class.

There were significant differences in soluble solids among the varieties which is a measure of sweetness. Road Trip, 9651, Turnpike, Unbridled, ORS 6260, Kingman, 7197, Embasy and Captivation had the highest soluble solids levels. All of the varieties had average soluble solids of over 10% with the exception of XWT 6009 and ORS 9033 B.

Hollow heart defects can render watermelons unsaleable. No hollow heart was observed in Mini Bee, Joy Ride, ORS 6260, ORS 6278, ORS 6305, ORS 6253 and Summer Breeze. Turnpike had high levels of hollow heart. Those additional varieties with one or more fruit with major or severe hollow heart (10% unsaleable) were SV 0241, and 9601.

Hollow Heart

Research from 2010-2017 in Delaware showed that hollow heart disorder in triploid seedless watermelon was more severe in pollen limiting environments, incidence was higher with increasing distance from a pollen source, and that varieties differed in susceptibility to hollow heart with higher flesh density varieties having less hollow heart. The theory that pollination, hormone activity, and cell division in early watermelon fruit development determines hollow heart incidence and severity is being pursued. In 2014 a study was designed with the diploid pollinizer variety 'Stargazer' planted between plants of a higher flesh density triploid watermelon '9651HQ' and a lower density flesh watermelon 'Liberty' in 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, and 1:8 pollenizer to seedless ratios progressively in the row. There was a linear decrease in triploid flesh density from 1:1 to 1:8 ratios of 19% and 9651HQ was consistently 5% more dense than Liberty. There was a curvilinear relationship between hollow heart severity ratings and pollinizer ratio. In 9651HQ hollow heart was not found until a 1:4 ratio, was found at low severity in 1:5,1:6 ratios, increased significantly at the 1:7 ratio, and then increased greatly at a 1:8 ratio. The triploid Liberty showed a similar relationship but did have some hollow heart at all ratios. This study further confirms that limiting pollen increases the incidence and severity of hollow heart. It also shows that limiting pollen decreases watermelon flesh density. Additional trials in 2015 and 2017 confirmed these results.

2017 Seedless Watermelon Variety Trial: Varieties by Marketable II Yield (excluding fruit less than 9 lbs and over 24 lbs[1]) in Lbs/a and Fruit/a and Fruits per Harvest

Variety	Yields and Harvest Distribution						
					Fruit per harvest		
	Marketable II lbs/a		Marketable II Fruits/a		Harvest 1 78 DAT	Harvest 2 95 DAT	Harvest 3 115 DAT
Crunchy Red	121959	a	7318	bcd	4264	1498	1556
9651	114889	ab	7663	bc	3688	2996	980
Turnpike	110372	abc	6799	cde	2881	3457	461
SV 0241 WA	102247	abcd	6453	cdef	3457	2708	288
Warrior	101410	abcd	6280	cdef	3284	2247	749
9601	101122	abcde	6050	cdefg	2593	2708	749
Kingman	95262	abcdef	6280	cdef	3169	2305	807
Fascination	95020	abcdefg	5820	cdefgh	3457	1786	576
ORS 7033 B	93766	abcdefg	9968	a	5474	3515	980
KB 10770	92110	bcdefg	5359	efghij	3515	1786	58

XWT 6008	91813	bcdefg	5762	defghi	3457	2132	173
ORS 6151	90850	bcdefg	6338	cdef	3745	2074	519
XWT 6009	90308	bcdefg	5416	efghij	2535	2650	230
7197	89906	bcdefg	5416	efghij	2996	1901	519
7187	88418	bcdefg	5243	efghij	2650	2247	346
Unbridled	85994	bcdefg	5186	efghij	2305	2478	403
Captivation	84995	cdefgh	4898	fghijk	3054	1152	691
Wolverine	84220	cdefgh	5070	efghijk	2766	1556	749
ORS 6253	78858	defghi	4955	efghijk	3918	691	346
Charismatic	76168	defghi	4610	fghijkl	3111	1268	230
Secretariat	75201	defghi	5186	efghij	2535	2132	519
Road Trip	71539	efghi	4149	hijkl	2362	1095	691
Embasy	70045	fghi	4379	ghijkl	2190	1671	519
Maxima	69804	fghi	3918	ijkl	2420	922	576
Joy Ride	69242	fghi	3976	hijkl	2132	1383	461
WDL 2413	67868	fghi	4149	hijkl	2535	1152	461
Bottle Rocket	67201	fghi	3803	jkl	2362	1037	403
Mini Bee	66605	fghi	8931	ab	4725	3515	691
ORS 6260	66572	fghi	4264	ghijkl	2996	864	403
Summer Breeze	65893	fghi	4033	hijkl	2247	1440	346
ORS 6278	65467	ghi	3976	hijkl	2362	691	922
ORS 6305	56157	hi	3284	kl	1901	980	403
SV 3105 WA	51768	i	2823	l	1959	807	58
[1]Mini Bee and ORS 7033B includes smaller sizes							
p-value	***0.0002***		***0.0001***				
$LSD_{0.05}$	**29641**		**1877**				

NEW DEVELOPMENTS IN MANAGING POWDERY AND DOWNY MILDEWS IN CUCURBITS

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Managing diseases is an important component of a successful production program for cucurbit crops because there are several diseases that can reduce yield or fruit quality when not adequately managed. The mildews are among the most common. Fungicides are an important tool for managing diseases. Resistant varieties can be valuable components of an integrated management program, but typically when used without fungicides will not achieve sufficient control to avoid a reduction in yield or fruit quality. Fungicides recommended routinely change as new products are registered and pathogens develop resistance to fungicides that have been in use for several years. Modern fungicides because of their targeted mode of action typically have medium to high risk for resistance to develop in the pathogen. These need to be used in alternation to delay development of resistance, avoid control failure when resistance develops, and comply with label use restrictions.

Powdery mildew. An integrated program with both management tools (resistant varieties and fungicides) is recommended to maximize likelihood of effective control and reduce selection pressure on the pathogen to overcome one of these tools. It has demonstrated ability to evolve and become less effectively controlled by both tools. Resistant cucumber varieties have a exceptional level of resistance and often develop no symptoms. Resistant melon varieties have race-specific resistance. Those with resistance to pathogen races 1 and 2 have not exhibited as high a level of powdery mildew suppression in recent trials as in the past indicating the pathogen has likely changed again. Resistant pumpkin varieties like Progress with a resistance gene from both parents (PMRR, homozygous) have been less severely affected by powdery mildew than varieties with a resistance gene from one parent which confers intermediate resistance. Later were not significantly less severely affected than a variety with no resistance in recent trials.
Alternate among targeted, mobile fungicides in the 5 chemical groups below (listed in recommended order), and apply with protectant fungicide to manage resistance development. Begin very early in disease development (one older leaf out of 50 with symptoms).

Vivando (FRAC Code U8) is a new fungicide with a new mode of action. Cucurbits are on a supplemental label. It has exhibited excellent control in fungicide evaluations conducted recently. Activity is limited to powdery mildew. Do not mix with horticultural oils. It can be applied three times per year with no more than two consecutive applications. REI is 12 hr. PHI is 0 days.

DMI fungicides (Code 3) include Proline, Procure, and Rhyme (considered most effective) plus Aprovia Top, Folicur, Inspire Super, Mettle, Rally, Tebuzol, and TopGuard (also has Code 11 ingredient). Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Efficacy has varied in fungicide evaluations. Procure applied at its highest label rate provides a higher dose of active ingredient than the other Code 3 fungicides. Five applications can be made at this rate. REI is 12 hr for these fungicides. PHI is 0 - 7 days. Powdery mildew is the only labeled cucur-bit disease for these fungicides, except for Proline (labeled for Fusarium), Rhyme (gummy stem blight), and Aprovia Top and Inspire Super, which contain another active ingredient (Code 7 and 9, respectively) and are labeled for additional diseases (see last section).

Quintec (Code 13) has been consistently effective in fungicide evaluations although resistance was detected in 2015. Activity is limited to powdery mildew. Label specifies no more than two consecutive applications plus a crop maximum of four applications, and no aerial applications. REI is 12 hr. PHI is 3 days. Limited use is suggested.

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

Torino (Code U6) has exhibited excellent control in fungicide evaluations until recently. It provided poor control in an experiment at LIHREC in 2017 and in NC in 2016. Activity is limited to powdery mildew. It can only be applied twice to a field in a 12-mo period. Consecutive applications are not recommended. REI is 4 hr. PHI is 0 days. Limited use is suggested.

Resistance continues to be very common to MBC fungicides (FRAC code 1; Topsin M) and QoI fungicides (Code 11; Quadris, Cabrio and Flint); therefore these are not recommended.

There are several protectants for powdery mildew, including chlorothalonil, sulfur, copper, botanical and mineral oils, and several biopesticides. Sulfur and oils have good efficacy.

Downy mildew is primarily managed with fungicides. Resistance has only been bred in cucumbers. Varieties with a new source of resistance are becoming available. Some suppression, albeit variable, can be obtained with varieties bred to be resistant to pathogen strains present before 2004. In a variety evaluation conducted on Long Island in 2017 under very high disease pressure, DMR 401 exhibited the highest level of resistance, Bristol and Citadel (pickling type suitable for fresh market) were moderately resistant but were not significantly less severely affected than SV3462CS, SV4719CS, and Diamondback. Marketmore 76 exhibited limited resistance while Speedway was not significantly less severely affected than Straight Eight, the susceptible check variety. In evaluations conducted in 2016 and 2017 at University of Massachusetts, NY264, DMR 401 (both sold at http://commonwealthseeds.com/), and Bristol exhibited good resistance with NY264 and Bristol performing best under high disease pressure.

An integrated program with fungicides applied to resistant varieties is recommend. As with powdery mildew, fungicide resistance is also a concern with the downy mildew pathogen and therefore the fungicide program recommended is also targeted, mobile fungicides applied in alternation based on FRAC Code (see list below) on a weekly schedule and tank mixed with a protectant fungicide (chlorothalonil or mancozeb) beginning very early in disease development.

An important tool for determining when fungicide application is warranted is the forecast web site for this disease at http://cdm.ipmpipe.org. Cucurbit plants are susceptible to downy mildew from emergence; however, this disease usually does not start to develop in the northeast until later in crop development when the pathogen is dispersed by wind into the region. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. The pathogen needs living cucurbit crops to survive, thus it cannot survive where it is cold during winter. The risk of downy mildew occurring throughout the eastern USA is forecast and posted three times a week. Forecasts enable timely fungicide applications. Label directions for some fungicides state to begin use before infection or disease development. The forecasting program helps ensure this is accomplished. Growers can subscribe to receive customizable alerts by e-mail or text message. Information is also maintained at the forecast web site of cucurbit crop types being affected by downy mildew. This is important because the pathogen exists as pathotypes that differ in their ability to infect the various crops. All pathotypes can infect cucumber; some also can infect melons and squashes are susceptible to others. Success of the forecast system depends on knowledge of where downy mildew is occurring; therefore prompt reporting of outbreaks by growers is critical.

Fungicides for downy mildew (DM) and/or Phytophthora blight (PB):
Both diseases often are of concern in a crop. Many of the same targeted fungicides are labeled for both as they are caused by oomycete pathogens.

Presidio (FRAC Code 43). Recommended used early in the season for PB when DM not a concern. No longer effective for DM because of resistance. Apply no more than 4 times in a season with no more than 2 consecutive applications. Must be applied with another fungicide.

Orondis (49). The novel active ingredient, oxathiapiprolin, has exhibited excellent activity in fungicide evaluations. It is formulated with mandipropamid as Orondis Ultra (REI is 4 hr) and with chlorothalonil as Orondis Opti (REI is 12 hr). PHI is 0 day.

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

Zing! and Gavel (22). These are the only products that have a targeted fungicide and a protectant fungicide (chlorothalonil or mancozeb). Only Gavel is labeled for PB as well as DM. REI is 12 hr for Zing! and 48 hr for Gavel. PHI is 0 and 5 days, respectively. Apply no more than 8 times in a season with no more than 2 in succession. Limit total use with all products used to 1.6 lb zoxamide and 9.44 lb chlorothalonil per acre per season. The amount of chlorothalonil in an application of Zing! (1.18 lb/A) is less than the highest label rate of chlorothalonil fungicides for downy mildew (1.5 lb/A) and is below the range for other diseases including powdery mildew (1.5-2.25 lb/A). Increasing the amount of chlorothalonil applied is prudent for these diseases. To obtain an application rate of 1.5-2.25 lb/A chlorothalonil, tank mix Bravo WeatherStik at 0.43-1.43 pt/A with Zing!.

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

Zampro (40, 45) and Revus (40). While in the same fungicide chemical group (40), there is indication they may have slightly different mode of action, thus there may be benefit to using one for the first application of a product in this group in a fungicide program and then switching to the other product later in the program. REI is 12 hr. PHI is 0 day. Apply no more than 3 times (4 for Revus) in a season with no more than 2 consecutive applications (none with Revus). Revus must be applied with a spreading/penetrating type adjuvant. Revus is recommended used sparingly because of suspected resistance. Forum is no longer recommended; it has the same FRAC Code 40 ingredient as Zampro.

Ariston, Curzate or Tanos (27). These have some curative activity (up to 2 days under cool temperatures) but limited residual activity (about 3-5 days). They can be a good choice when it was not possible to apply fungicide at the start of a high risk period when temperature is below 80 F. Apply another targeted fungicide 3-5 days later. Curzate and Tanos must be tank-mixed with a protectant; Ariston also contains chlorothalonil. REI is 12 hr. PHI is 3 days. Apply no more than 4 times in a season (6-9 for Curzate depending on rate); no consecutive applications of Tanos are permitted. Ariston and Curzate are not labeled for PB.

Phosphorous acid fungicides (33). There are numerous products (e.g. Agri-Fos, Fosphite, K-Phite, Phostrol, ProPhyt, Rampart), all effective only for PB. They are recommended used at a low label rate tank mixed with the targeted fungicides listed above for PB.

Previcur Flex (28). Activity is limited to DM. Use sparingly (less than label limit of 5 times in a season) because of suspected resistance. REI is 12 hr. PHI is 2 days.

Recommended protectant fungicides. Chlorothalonil and mancozeb are the main protectant fungicides for DM and PB. Copper is also good for PB, but isn't as effective for DM.

No longer recommended for downy mildew. Resistance to mefenoxam and metalaxyl (Ridomil) and to strobilurins (e.g. Cabrio) are sufficiently common that fungicides with these ingredients, which use to be highly effective, have been ineffective since 2004.

It is suspected that some strains of the downy mildew pathogen, in particular those infecting cucumbers, have developed resistance to other fungicides based on the fact they have exhibited reduced efficacy, compared to prior efficacy, in fungicide evaluations and also based on fungicide seedling bioassays. Fungicides that have exhibited signs of being affected by resistance include Presidio, Previcur Flex, Revus, Forum, Curzate, Tanos, and Zampro. This research was done with cucumber because downy mildew occurs most commonly on this cucurbit crop type. Some variation in results among locations has been detected. For example, Zampro was effective in seedling bioassays conducted on Long Island in 2016 and 2017, but not in bioassays conducted in South Carolina. Additionally, a recent study revealed that the pathogen strains obtained from pumpkin are often genetically different from those from cucumber.

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede this information, if there is a conflict. Before purchase, make sure product is registered in your state. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

Farm Brewery Crops (am)

THINKING OF GROWING CROPS FOR CRAFT BREWING - SOME CONSIDERATIONS FOR FARMERS

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The National Association of Brewers reports that 75% of 21+ year olds live within 10 miles of a local brewery. The resurgence of local brewing in America is certainly evidenced by the more than 4,000 active American breweries contained in the National Association of Brewers database. In fact the US is currently approaching the historical high of 4,131 breweries reported in 1871. Craft beer is in many ways a reflection and driver of the local food movement. In an age of massive corporate brands, people are thirsty for experiences like riding a bike or hiking to the local brewpub and having a beer produced with local ingredients. Very similar to the consumer’s desire to source and purchase locally produced fruits and vegetables. Unlike a chef in a local restaurant, craft brewers can find it to be difficult to source locally-grown hops, barley and other ingredients in the U.S. That’s starting to change as brewers seek out more local ingredients. The rise of the local food and drink movement has led to a surge in beer made with items like local honey, fresh fruit or local “wet” (green) hops. There are also an increasing number of breweries trying to source items such as local barley, and that’s helping to fuel farmer’s interest in production of these ingredients.

The idea of producing specialty and niche market crops is a fairly unfamiliar concept to traditional grain farmers in the northeast region. Grain farmers are typically geared to producing for the commodities market where price is largely determined by CBOT pricing. In this model there are generally no price premiums paid for producing superior products. The typical measure of success is measured solely in terms of yield. Many opportunities for specialty or niche market crops presented to farmers at extension and industry meetings are vegetable or fruit crops. Grain producers tend to shy away from such ventures as it often would require investing in additional equipment for production, packaging etc. Such opportunities would require the grain farmer to learn about producing a commodity they have no experience with. These opportunities often require the grain farmer to operate outside of their comfort level. However, recently opportunities for producing specialty and niche grains have become increasingly more available. This is particularly attractive to existing grain farmers as they have the knowledge and understanding to produce grain crops. In addition there are generally minimal capital and infrastructure changes which must be made to produce these crops. An emphasis on higher quality products over traditional commodity grade is one of the usual defining characteristics the specialty markets are seeking. Organically produced and GMO free may also be additional considerations. Alterations to crop production and management are generally the predominate changes that must be made. The transition to producing such crops is generally easier for an existing grain farmer. The most readily apparent market for grain farmers is the craft brewing and distillery markets. However, entering these markets is not without out risk. Producers must be aware of market demands and locations, contract and delivery requirements, as well as specific crop production and storage techniques. Many producers have ventured into these niche markets without conducting adequate research and have unfortunately failed.

Similarly, the production of locally produced hops is a niche market that many existing and new farmers have expressed interest in. The production of hops in the Northeast is not an entirely new concept. In the later portion of the 1800s US hops production was primarily located in central New York State. As local craft brewers attempt to purchase local ingredients many farmers have expressed interest in meeting the demand for local hops. Potential hop producers are often counseled by cooperative extension to conduct market and production research before planting their first hop bine. Producers should be aware that supplying locally produced hops in NJ can offer challenges with on-farm infrastructure, harvesting and processing expenses that must be considered on a case by case basis. Before attempting to plant a hops yard, it is recommended to conduct market research to determine who will purchase your hops, approximate sale price, what varieties your customer is looking for, and whether the customer is seeking fresh or pelletized hops.

Presented will be information potential producers of ingredients for the craft brewing industry should consider or research before planting their first crop.

NJ HOPS QUALITY – WHAT WE KNOW FROM RUTGERS RESEARCH

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In 2016, the National Brewers Association reported that there were 82 breweries in New Jersey. This number continues to rise. As new breweries open, there has been increasing interest in sourcing locally grown ingredients. However, hops, which lend flavor and aroma to beer, have historically been grown in the pacific north western (PNW) United States. This has been due, in large part, to disease pressure in other regions including New Jersey. Disease management methods have improved significantly for hops, and it has recently become more feasible to grow them in New Jersey than ever before.

Although hop cultivation in New Jersey has become a more viable venture, there are still large hurdles involved in establishing a hop yard. These hurdles include sourcing clean plant material, procuring 25 ft. trellising, and obtaining equipment to reach, tie, and string hop bines. The focus of this talk will be on an additional hurdle to hop farming, harvest and post-harvest handling, how those steps effect hop quality, and the importance of producing a high quality hop crop.

Making decisions on when to harvest, how to harvest, and how to dry and process hops are all complex but important steps in ensuring hop cones meet quality standards set forth by the PNW hop industry. In order to meet these quality standards, hops must contain high enough levels of several chemical compounds (alpha and beta acids and an array of aromatic compounds) involved in imparting flavor and aroma to beer.

Preliminary work has been done through the New Jersey Agricultural Experiment Station (NJAES) and Professor Jim Simons New Use Agriculture and Natural Plant Products Laboratory (NUANPP) laboratory to procure baseline information on the levels of alpha and beta acids and aromatic compounds in hops grown throughout New Jersey. Three years of hop quality data have been obtained through this project, which will be presented, and shows hops grown in New Jersey can meet PNW quality standards.

The final component of the presentation will involve a short discussion on the importance of farmers having their hops tested as a means of quality assurance for brewers. In addition this information can potentially help farmers garner a higher profit for their crop. As of 2017 approximately 8 farms in NJ have utilized the

NJAES/NUANPP laboratory hop testing service. This represents only a subset of the total number of farmers thought to be growing hops in New Jersey. The NJAES will continue to provide these hop testing services through Jim Simons NUANPP laboratory for the 2018 growing season. With the overarching goal of helping farmers produce and promote consistent high quality hops for brewers in New Jersey and throughout the northeast.

Gazing into the Crystal Ball – New Technologies in Ag

ROBOTS IN THE FIELD – AUTOMATION FROM SEEDLING PRODUCTION THROUGH HARVESTING

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Rapid advances in computers, miniaturization, sensors (vision and other), and robotics are allowing innovative developments in the automation of labor-intensive horticultural crop farming that were once thought to be too expensive to employ except in large agronomic crop production. From seedling production through transplanting, plant monitoring, pest management right through to harvesting and post-harvest handling, this presentation will explore some of the new devices that are being introduced to the market now and in the near future to automate vegetable production.
Coupled with concerns about a stable labor supply and costs of labor in general, automation of many manual tasks, that has not been possible in the past, is receiving renewed attention by innovators from around the world. Exciting new tools will help farmers produce crops more efficiently and with less labor. Private and public engineers and horticulture researchers are combining efforts to provide solutions to critical tasks that are among the most time consuming, expensive and often monotonous requirements for growing fresh produce.
Some of the systems that will be reviewed in this presentation include:

- Plant Tape USA – automatic high speed transplanting system for lettuces & greens
    - planttape.com, Salinas, CA

- Blue River Technology 'Lettuce Bot' – "See & Spray" computer vision-controlled thinning of seedlings and selective weeding (acquired by Deere & Co, Sept 2017)
    - bluerivertechnology.com, Salinas, CA

- Robotic Harvesting, https://www.wired.com/video/2017/05/robots-us-how-food-bots-are-changing-how-we-eat/
    - Taylor Farms California - Lettuce, http://www.taylorfarmsfoodservice.com/whats-trending/taylor-farms-automated-harvesting-company/
    - Abundant Robotics - Apples, Menlo Park, CA https://www.youtube.com/watch?v=mS0coCmXiYU
    - Harvest Croo Robotics - Strawberries, Plant City, FL http://www.harvestcroorobotics.com/

- Greens Harvesting – Italian Harvesting machines
  - Spimaro Harvester, https://www.youtube.com/watch?v=3aN2KOBvsxw
  - ORTOMEC Italia, https://www.youtube.com/watch?v=XYCIL2aZNE8
  - Terrateck Sas, https://www.youtube.com/watch?v=6-AWEIjogiU
  - Quick Cut harvester, https://www.youtube.com/watch?v=OPIfw5_WoLU, http://www.farmersfriendllc.com/
  - MORE AT:
    - http://www.agriexpo.online/agricultural-manufacturer/vegetable-harvester-537.html
    - https://www.hortech.it/en/cp/agricultural-machineries-for-harvest/

MONEYBALL IN FRUIT AND PRODUCE PRODUCTION: USING DATA TO MAKE BETTER DECISIONS

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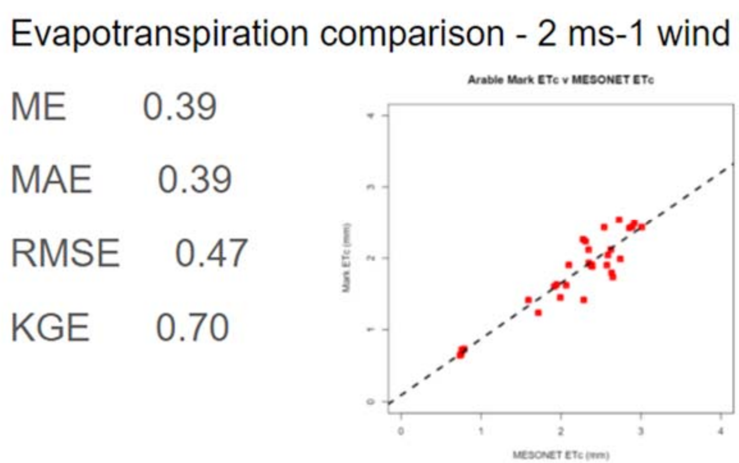
Agriculture is a risky business: it's a wonder anyone makes a living! Along with predictable headaches like complying with food safety and labor regulations, there are random events in the agronomy and contracts that represent the interaction of biology of specific varieties with weather in particular microclimates. At Arable, our focus is in monitoring plants and weather to better monitor chronic issues such as providing the right water and nutrients, alert for episodic risks such as disease outbreaks, heat stress and frost, and predict the final harvest, including timing, quality and yield. While each crop has its own key sensitivities owing to its specific biology, our plant and weather monitoring tools have been successfully applied to a number of different crops grown in New Jersey, including tomatoes, leafy greens, winegrapes, berries, and hops. In this talk, I will give an overview of examples where we have applied crop-specific and microclimate-specific models to give producers and processors foresight to make difficult decisions easier.

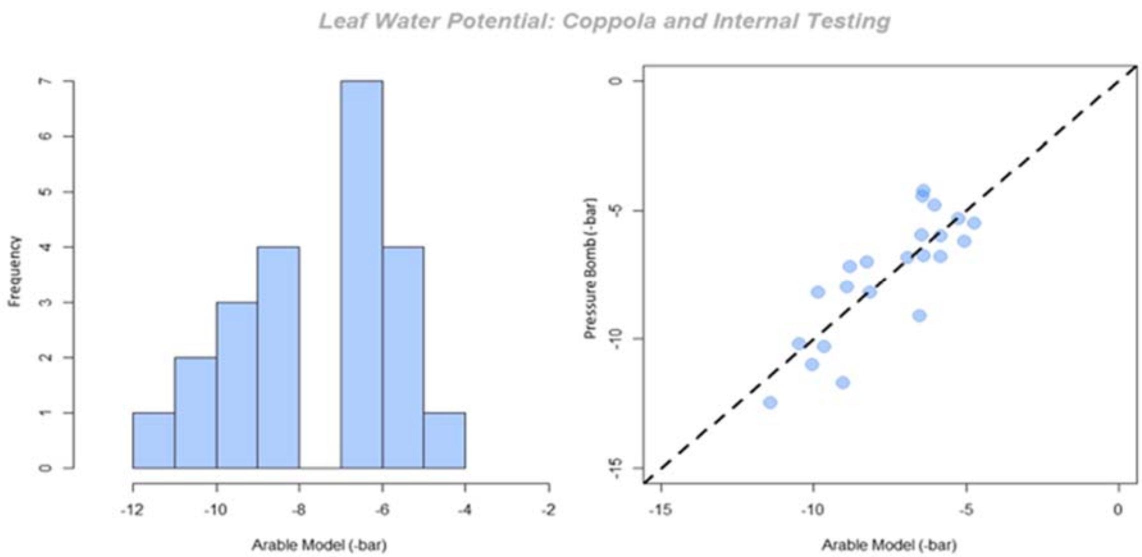
Water

The Arable Mark measures four-component net radiation, along with canopy cover, which are the key determinants of field-specific water demand (ET). We showed in a comparison with the Nebraska Mesonet that we could achieve comparable accuracy at a small fraction of the cost, enabling water to be applied with much greater precision.



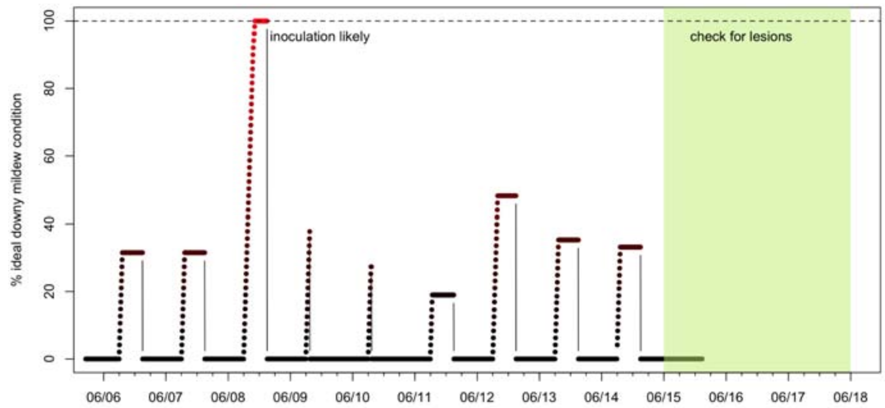
In a research effort funded by the USDA NRCS Conservation Innovation Grants, we showed that this efficiency could result in a water savings of 21% in processing tomato production in California. Lowering water applications could have direct benefits to increasing brix in tomatoes, which can achieve a price premium.

Some production systems, like winegrapes, measure water potential as a guide for irrigation decisions, rather than ET. We showed that the leaf the air temperature difference measured by the Mark, in combination with vapor pressure deficit and net radiation could provide continuous estimates of water potential. These help guide efforts to meet target moisture levels to achieve desired vine stress, to ensure high grape quality. The ability to measure continuously helps to improve the data quality and quantity, and reduce the demand for laborious data collection.

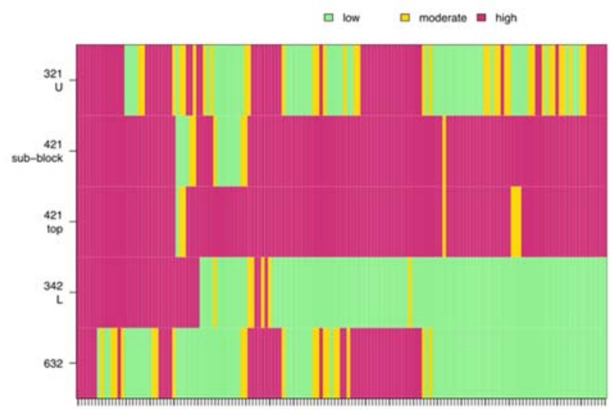


Disease

The Arable Mark measures canopy temperature, which can be used to determine whether there is condensation on the leaf, if this temperature drops below the dewpoint. We applied this measurement to understand downy mildew risk in greens and herbs, and discovered that risk crosses an infection threshold on a small number of days, which can focus scouting effort.

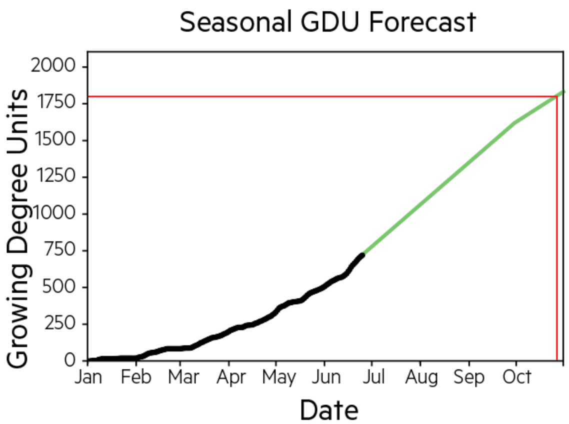


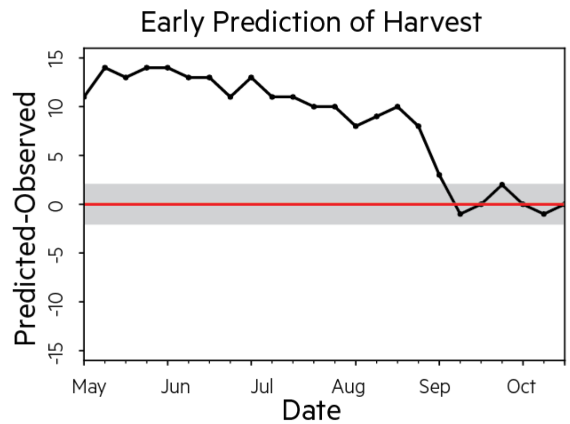
These same measurements were used to monitor powdery mildew in winegrapes, and found that despite the perception of constant risk, some sites could be spared spraying a significant fraction of the year.



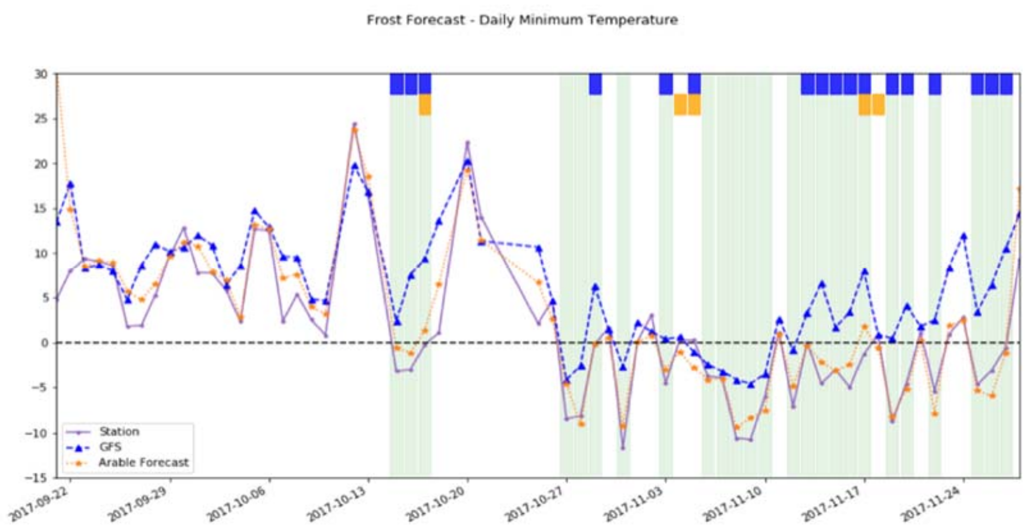
Harvest Timing

We have used the data collected by the Mark to improve seasonal forecasts available from NOAA, specifically around timing of harvest. Better prediction of harvest helps secure scarce labor, and plan operations to ensure high fruit quality with low losses. We showed the ability to predict harvest within 2 days from 6 weeks prior.





These same data were also used to improve frost forecasting, improving the ability to predict frost 3:1 over GFS



PRODUCE FOR MEAL KITS – SPECIAL CONSIDERATIONS FOR AN EMERGING INDUSTRY

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Blue Apron, the largest meal kit company in the US, helps make incredible home cooking accessible to everyone by providing home chefs across the country with pre-portioned fresh ingredients and recipes each week. High quality, fresh produce is an essential and prominent component of all our meals. However, shipping raw ingredients to cook complete meals all over the continental US introduces many unique challenges and opportunities, especially in regards to produce selection, procurement, and packaging. In our box and mail based model, there are critical considerations around product sizing, freshness, shelf life, temperature, and humidity sensitivity. Further, because we aspire to transcend mere food delivery by creating incredible experiences for our customers, the surprise-and-delight element of the produce we include in each box is all-important. To this end, Blue Apron has partnered with hundreds of growers and other produce purveyors to source dozens of varieties of specialty produce for our fulfillment centers in Linden, NJ, Arlington, TX and Richmond, CA. From fairy tale eggplants to fuyu persimmons, we introduce our customers to delicious and beautiful items not commonly available in their neighborhood grocery stores. I will share learnings on all these topics gathered from our first 5 years in business that are relevant to the produce industry in NJ.

Soil Health Management

UTILIZING COVER CROPS FOR SOIL DISEASE SUPPRESSION

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A previous version of this was published as a fact sheet "Soil Biology: Cover Crops and Disease Suppression" as part of the 2016 Southern Cover Crops Conference and has been edited and updated here. The 2016 Southern Cover Crops Conference was supported from the southern Sustainable Agriculture Research and Education (Southern SARE) program, which is funded by the U.S. Department of Agriculture – National Institute of Food and Agriculture (USDA-NIFA). Any opinions findings, conclusions or recommendations expressed within do not necessarily reflect the view of the Southern SARE program or the U.S. Department of Agriculture.

Cover crops provide many benefits to soil health such as improving soil structure, reducing the need for synthetic chemicals by decreasing weed biomass, increasing soil organic matter, contributing nutrients to the soil, retaining soil moisture, and decreasing soil erosion. In addition, the integration of cover crops into crop production often leads to soils that are suppressive to plant diseases (i.e. have less potential for disease development). Disease reductions may occur in fields where the cover crop is planted in the fall and tilled under in the spring as a green manure prior to planting the cash crop, as well as when the cover crop is killed and the residue is left on the soil surface as a mulch.

Mechanisms of Disease Suppression: The mechanisms of cover crop-induced disease suppression are not yet fully understood. However, several common mechanisms are thought to be involved in the "general suppression" of soil-borne plant diseases. Disease may be suppressed due to an increase in the overall activity and diversity of the soil microbiota (microorganisms that inhabit the soil) that occurs with cover crop production. Greater microbial diversity and activity results in increased competition with plant pathogens for nutrients and release of more compounds that interfere with the ability of plant pathogens to grow and develop. Some cover crops impact plant pathogens directly by releasing fungitoxic compounds (compounds that are toxic and subsequently unfavorable to the growth of fungi). In addition to increasing competition with soil-borne plant pathogens, these changes may also impact diseases because decomposing organic matter may increase fungistasis. Fungistasis occurs when a soil-borne plant pathogen's growth and infection is inhibited, even under optimal soil conditions. Fungistasis results from the presence of volatile compounds and/or the reduction in organic carbon compounds and nutrients. One example of a cover crop that may trigger several of these impacts is mustard greens (*Brassica juncea*). Mustard greens contain high levels of glucosinolates, which are sulfur containing chemicals that have fungicidal and nematicidal properties. The glucosinolates in mustard greens induce high levels of biological activity (mostly antimicrobial) and successfully suppress the occurrence of *Rhizoctonia* on potatoes through the release of isothiocyanates into the soil. In addition to direct effects on plant pathogens, many cover crops impact plant pathogens indirectly by triggering the plants' host defense response (a plant's immune response that protects it from infection).

Cover crops may also induce "specific suppression" by enhancing individual beneficial organisms. An example of an organism that induces specific suppression is the fungus *Trichoderma harzianum*, which suppresses *Pythium*, *Fusarium* spp. and other soil-borne pathogens of beans, and many other vegetable crops. Suppression by *T. harzianum* is thought to be due to competition for nutrients. *Trichoderma* is able to colonize many cover crops including annual ryegrass (*Lolium multiflorum*), red clover (*Trifolium pretense*), hairy vetch (*Vicia villosa*), and winter wheat (*Triticum aestivum*). Its ability to survive at high populations and colonize a subsequent cash crop is related to the cover crop root mass, time of cover crop termination, and other factors. In one study, winter wheat and canola (*Brassica napus*) resulted in the best carry over of *Trichoderma*. Due to its ability to reduce some diseases, one species of *Trichoderma*, *T*. *harzianum*, has been formulated into a commercial biocontrol product.

Mycorrhizae (fungi that live in association with plant roots and benefit the plant by aiding in water and nutrient absorption) may suppress individual diseases. Cover crops influence the quantity and composition of mycorrhizae in soils and on the subsequent cash crop. Investigators have observed enhanced mycorrhizal populations in peach, tomato, corn and watermelon following a mycorrhizal cover crop. For example we observed an increase in arbuscular mycorrhizal colonization in watermelon grown after a hairy vetch or crimson clover (*Trifolium incarnatum)* cover crop. These cover crops improved mycorrhizal colonization of the watermelon roots and also reduced Fusarium wilt.

No-till and Disease Suppression: No-till cover crops provide many of the benefits just described and, additionally, provide a physical barrier that reduces the splash of soil and soil-borne pathogens onto foliage, stems, or fruit. The cover crop can also reduce the presence of free moisture on the plant because they reduce soil splash. Septoria leaf spot severity was reduced on tomatoes grown in a hairy vetch cover crop mulch, and the reduction was due to reduced soil splash to the tomato leaves. Foliar and fruit rot diseases of pumpkin such as white fleck (caused by *Plectosporium tabacinum*) and black rot (caused by *Didymella bryoniae*) are often lower when the crop is grown on a no-till hairy vetch, cereal rye (*Secale cereale*), or hairy vetch plus cereal rye cover crop. The reduction may be due to the formation of a cover crop vegetative layer between the fruit and soil reducing soil splash and shortening the length of time the fruit remain wet throughout the day.

Cover Crop Management: Selection of a cover crop depends on many factors including its ability to suppress disease. In considering a cover crop for disease suppression, consider field history and what diseases have been observed in the past. In addition, consider future crops and their potential pathogens. Table 1 is a partial summary of research-based information on specific cover crops that have successfully reduced diseases. Cautionary notes are also included.

Cover crops, even those commonly associated with disease suppression, can under some circumstances increase other diseases (Table 1). In addition, timely incorporation of a cover crop is very important because late incorporation, which occurs too close to planting the cash crop, may increase pathogens such as *Pythium* spp. A short interval between rye cover crop termination and incorporation and corn planting has led to decreased emergence and stunting, especially when cold and wet conditions occur. It is important to maximize biomass of the cover crop, however the cover crop must be incorporated to insure enough time to breakdown, usually several weeks, prior to planting. Like all plants, cover crops get diseases and therefore can host plant pathogens, increasing the population present on the subsequent cash crop. For example, hairy vetch is a host of root knot nematode. White clover (*Trifolium repens*) and buckwheat (*Fagopyrum esculentum*) cover crops increased bean root rot where *Fusarium, Pythium*, and *Rhizoctonia* were present. Though brassica cover crops suppress many diseases, there also are reports of an increase in *Fusarium* disease severity following brassica cover crop incorporation. This increase may have resulted because a *Brassica* cover crop decreases the mycorrhizal colonization of the succeeding cash crop. For example, when tomato was planted after a mustard (*Allaria petiolata*) cover crop the tomato roots had lower mycorrhizal colonization than in the absence of the cover crop. A *Brassicaceae* cover crop (*B*. *juncea*), planted prior to corn or watermelon, reduced mycorrhizal colonization of these crops. The use of cover crop mixtures, timely incorporation of the cover crop into the soil or selection of a different cover crop can minimize these problems.

BIOFUMIGATION AND REDUCED TILLAGE FOR MANAGING PHYTOPHTHORA AND OTHER SOIL-BORNE PATHOGENS

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Researchers and subsequently vegetable growers in the Northeast have been using mustard biofumigation and reduced tillage to primarily manage Phytophthora blight and improve soil health mostly for pumpkin and winter squash. Sweet corn also does well produced with reduced tillage. These practices are suitable for other crops. Mustard plants produce glucosinolates, which breakdown as the plant decomposes into allyl-isothiocyanate, which is similar to methyl isothiocyanate, the active ingredient in the chemical fumigant Metam Sodium. Varieties have been developed with high glucosinolate levels for the purpose of biofumigation. Several seed companies now market them. Additionally, similar to other cover crops, when incorporated into soil the mustard plant tissue can increase water infiltration, soil tilth, and organic matter. Other types of plants have been used for biofumigation, including arugula, in particular the variety Nemat, targeting nematodes. There has been increasing interest in methods to reduce tillage recognizing its detrimental impacts on soil health. Deep zone strip tillage is a type of reduced tillage. Resulting soil health benefits, in particular improved soil water infiltration and increased microbial activity, are expected to suppress soil-borne pathogens, in particular *Phytophthora capsici,* which causes Phytophthora blight in cucurbits and several other vegetable crops.

Biofumigation. Keys to success include selecting a mustard variety developed for biofumigation, seeding early in the year (as soon as ground can be prepared) when preceding summer crop, applying fertilizer at minimum 50 lb/A nitrogen with sulfur if level in soil is low, preparing good seed bed, drilling seed rather than broadcast, providing irrigation when needed, flail chopping thoroughly (good equipment recommended) when mustard is flowering and temperature is cool, incorporating immediately (within 20 minutes of chopping), sealing the surface, irrigating if rain not imminent to maximize biomass, and disking lightly before planting at least 7 days later to release any residual fumigant gas as well as manage any weeds that germinated. At LIHREC mustard is incorporated the morning of a day with high probability of rain when possible. Seed start to mature about 6 weeks after the onset of flowering thus there is a long time period when incorporation can be done before risk of re-seeding. Another key is using biofumigation as a component of a management program that includes other cultural practices and fungicides.

At LIHREC, after several years of research, mustard biofumigation has become routine practice for managing Phytophthora blight before pumpkin powdery mildew fungicide evaluations. Other practices include drip irrigation with tape laid couple inches away from the plant crown, avoiding planting low areas in a field, subsoiling between rows before vining, and weekly preventive fungicide program. Research was conducted at LIHREC (on Long Island, NY) in fields naturally infested with *Phytophthora capsici*. Two replicated experiments were conducted. Mustard variety Caliente 199 was seeded at 10 lb/A on 8 April 2009 and 25 March 2010 with 0, 50, or 100 lb/A nitrogen. Mustard was flail chopped then immediately incorporated on 29 June 2009 and 14 June 2010, which were 4 and 2 weeks after first bloom, respectively. Next the soil surface was sealed with a cultipacker and irrigated. Acorn squash was direct-seeded or transplanted 2 weeks later. Biofumigated plots had fewer symptomatic fruit, yield was increased and fruit had higher Brix levels. With increasing rate of nitrogen fertilizer there was a trend toward greater mustard biomass and less Phytophthora blight. Three observational studies were also conducted. In the 2008 study, when Phytophthora blight was first observed, symptoms were found on almost all zucchini plants in the non-fumigated strip whereas only end plants were affected in the adjacent biofumigated strip, which also had fewer weeds. In 2011 there were several atypical intensive rain events creating very favorable conditions for Phytophthora blight, which was severe in all sections of this study, where different mustard varieties had been grown, as well as in other research fields and commercial fields where fungicide programs were used. In 2012 an integrated management program was implemented in a field where Phytophthora blight was severe in pumpkin the previous season. The program began with biofumigation and included a weekly preventive fungicide program. It was successful: fewer than 9% of pumpkins rotted.

Reduced tillage. Deep zone strip tillage is the type of reduced tillage researched at LIHREC. A 2-row Unverferth zone builder was used. For each row this piece of equipment has a 20-inch coulter to open the row, shank to disrupt plow pans and create compression fissures between the shanks and 2 17-inch wavy coulters followed by a 15-inch wide rolling basket to prepare the soil for planting. Row cleaners were added before the first coulter to move rye straw out of the strip being tilled. Rye was seeded the previous fall at a high rate (4.5 bu/A) with fertilizer when needed. When the rye was pollinating (mid-May to early June), it was rolled with a cultipacker twice, then sprayed with RoundUp herbicide. Pumpkins were seeded 1 to 2 weeks later with a standard vacuum seeder for tilled soil (not a no-till seeder). This delay allows soil settling. Row cleaners were added to push rye straw out of the seeded row. In the first few years of research, which was started in 2004, liquid fertilizer was injected into the soil with the zone builder. Then we switched to controlled release fertilizer put down during seeding in bands on both side of the seeded row, about 2 inches from the seed. Managing weeds can be more difficult in strip-tilled than conventionally-tilled fields because straw can interfere with herbicide reaching soil. It helps to use high rates and irrigate promptly to move herbicide to soil and activate it. Also applying a broad-spectrum herbicide like Round-Up manages weeds between strips and those that germinated in the strips after zone building. The research field at LIHREC dedicated to studying reduced tillage has 4 pairs of 20-ft-wide plots extending the length of the field (300 ft) managed every year with reduced or conventional tillage; a few years the field has been fallow.   When conditions were not unfavorable for Phytophthora blight (too dry), less fruit developed fruit rot in the reduced-till plots.

Growers have used reduced tillage for producing pumpkin, winter squash, cucumber, snap beans, cabbage, sweet corn, and sunflower. Where reduced tillage is used to manage Phytophthora blight in a field with a slope, it is best to orient rows across the slope. In a field where rows were parallel to the slope, the way blight developed it appeared that the pathogen had been moved in water that ran down the tilled strip. One grower added a second rolling basket to his Unverferth zone builder to improve the seedbed. Using reduced tillage to produce crops like sweet corn have been observed to be associated with less Phytophthora blight in susceptible crops grown with conventional tillage in rotation in that field compared to other fields on the farm where all crops in rotation were grown with conventional tillage.

Integration. In research studies and on commercial fields, improved control of Phytophthora blight was observed with biofumigation using mustard cover crops and also with reduced tillage practices. However, these practices were always used independent of each other. Growers were either using biofumigation successfully or reduced tillage successfully to manage Phytophthora blight. In 2016 a 2-year study was established at LIHREC to evaluate the integration of these cultural practices to further improve management of Phytophthora blight and enhance soil health. The theory was that in year 1, the practice of biofumigation will reduce the amount of inoculum in the soil and in year 2, the practice of reduced tillage will reduce crop contact with inoculum. A mustard cover crop was seeded the beginning of April 2016, allowed to flower, and flail chopped and incorporated mid-June. Kabocha squash was direct-seeded 10 days later. After harvest of the Kabocha, a rye cover crop was seeded at 4 bu/A and allowed to overwinter. In the spring of year 2, the rye cover crop was killed using a roller-crimper which laid the rye cover crop onto the soil surface like a mat. An Unverferth deep zone builder was used to establish rows and butternut squash was direct-seeded mid-June. In both years, Kabocha and butternut squash yields were improved with biofumigation and reduced tillage, respectively. Incidence of Phytophthora blight was minimal in both 2016 and 2017 due to dry conditions. More Phytophthora blight was observed in conventional bare-ground plots and in reduced tillage plots where rye mulch layer was thin and/or absent. A thick, rolled mulch layer and fostering a healthy, robust stand of mustard will improve management effects. Soil health data is currently being analyzed.

Successfully managing soil-borne pathogens. Effective management is more likely achieved when multiple practices are used. With Phytophthora blight this means using other cultural practices to minimize opportunities for soil to become saturated with water and applying fungicides targeted for oomycete pathogens on a preventive schedule. It is important for control and managing resistance to use several fungicides (different chemistry) in alternation, starting before symptoms are seen. Recommended fungicides (listed in order) and their label restrictions are Orondis (3 formulations, apply to soil or foliage, 1-9 applications depending on rate, max 2 sequential), Ranman (6, max 3 sequential), Omega (4-7 depending on rate), Presidio (2, none sequential; this is a recent label change), Gavel (8), Zampro (3, max 2 sequential), and Tanos (4, none sequential). A phosphorous acid fungicide is recommended included with these; there are no limits to their use.

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

PHYSICAL AND CHEMICAL COMPONENTS OF HEALTHY SOILS

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Creating a healthy soil environment is the most effective way to maximize nutrient availability, water uptake and ultimately, healthy, productive plants. There are many reasons that plants can or cannot absorb nutrients contained in the soil they are growing in and the process can be complicated. It is important to understand the physical and chemical components of soil and how they interact. Managing soils through tillage, cropping systems, and amendment applications can help improve soil health. The physical and chemical components of soil are explained below.

PHYSICAL COMPONENTS OF SOIL:

1. Horizonation

Soil “horizons” are individual layers that make up a soil profile. Typically, these layers are parallel with the ground surface. Listed below are some of the layers or horizons that make up some soils.

O horizons are dominated by organic material. Some are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated.

A horizons are mineral layers that formed at the surface or below an O horizon, that exhibit obliteration of all or much of the original rock structure, and that show one or both of the following:

- an accumulation of humified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons
- modification as a result of the actions of cultivation, pasturing, or similar kinds of disturbance

E horizons are mineral layers that exhibit the loss of silicate clay, iron, aluminum, humus, or some combination of these, leaving a concentration of sand and silt particles. These horizons exhibit obliteration of all or much of the original rock structure.

B horizons are mineral layers that typically form below an A, E, or O horizon and are dominated by obliteration of all or much of the original rock structure and show one or more of the following:

- Illuvial concentration of silicate clay, iron, aluminum, humus, carbonate, gypsum, or silica, alone or in combination
- Evidence of removal of carbonates
- Residual concentration of sesquioxides
- Coatings of sesquioxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying horizons without apparent illuviation of iron
- Alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky, or prismatic structure if volume changes accompany changes in moisture content; or brittleness

C horizons are mineral layers which are not bedrock and are little affected by pedogenic processes and lack properties of O, A, E or B horizons. The material of C layers may be either like or unlike that from which the overlying soil horizons presumably formed. The C horizon may have been modified even if there is no evidence of pedogenesis.

R horizons are layers of hard bedrock.
Transitional horizons are dominated by properties of one master horizon, but have subordinate properties of another. AB and B/C are examples of transitional horizon designations.

2. Soil Color

In well aerated soils, oxidized or ferric (Fe+3) iron compounds are responsible for the brown, yellow, and red colors you see in the soil. When iron is reduced to the ferrous (Fe+2) form, it becomes mobile, and can be removed from certain areas of the soil. When the iron is removed, a gray color remains, or the reduced iron color persists in shades of green or blue.

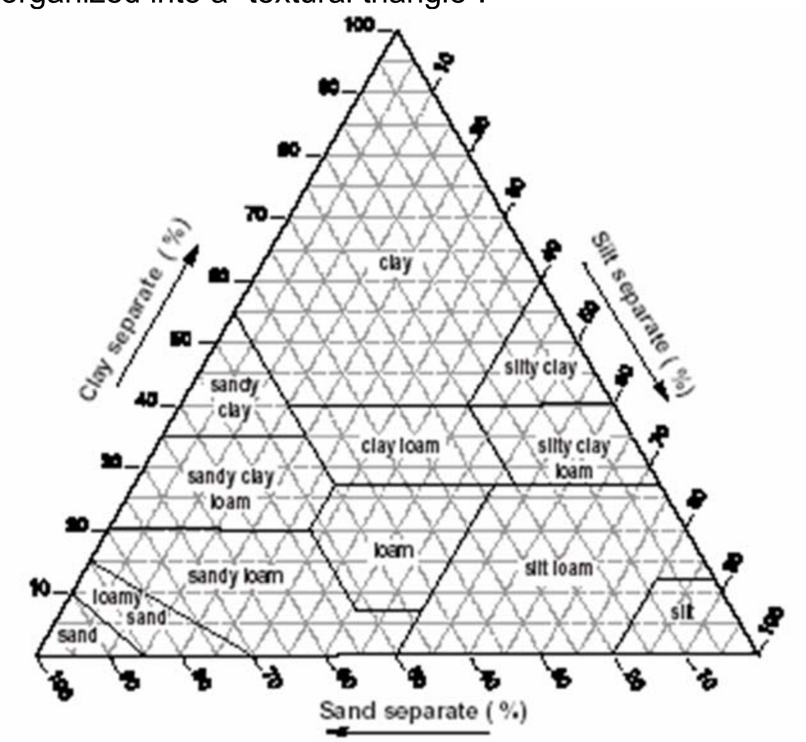
3. Soil Texture

Soil texture refers to the proportion of the soil “separates” that make up the mineral component of soil. These separates are called sand, silt, and clay. These soil separates have the following size ranges:

- Sand = <2 to 0.05 mm
- Silt = 0.05 to 0.002 mm
- Clay = <0.002 mm

Sand and silt are the “inactive” part of the soil matrix, because they do not contribute to a soil’s ability to retain soil water or nutrients. These separates are commonly comprised of quartz or some other inactive mineral.

Because of its small size and sheet-like structure, clay has a large amount of surface area per unit mass, and its surface charge attracts ions and water. Because of this, clay is the “active” portion of the soil matrix.
For all mineral soils, the proportion of sand, silt, and clay always adds up to 100 percent. These percentages are grouped into soil texture “classes”, which have been organized into a “textural triangle”.



Soil texture can affect the amount of pore space within a soil. Sand-sized soil particles fit together in a way that creates large pores; however, overall there is a relatively small amount of total pore space. Clay-sized soil particles fit together in a way that creates small pores; however, overall there are more pores present. Therefore, a soil made of clay-sized particles will have more total pore space than a will a soil made of sand-sized particles. Consequently, clayey soils will generally have lower bulk densities than sandy soils.

Collectively, the soil separates of sand, silt, and clay are called the “fine-earth fraction”, and represent inorganic soil particles less than 2mm in diameter. Inorganic soil particles 2mm and larger are called “rock fragments”.

When the organic matter content of a soil exceeds 20 to 35% (on a dry weight basis) it is considered organic soil material, and the soil is called an organic soil. As this material is mostly devoid of mineral soil material, they cannot be described in terms of soil texture. However, the following “in lieu of” texture terms can be used to describe organic soils:

- “peat”; organic material in which the plant parts are still recognizable
- “muck”; highly decomposed organic material in which no plant parts are recognizable
- “mucky peat”; decomposition is intermediate between muck and peat

4. Soil Structure

The soil separates can become aggregated together into discrete structural units called “peds”. These peds are organized into a repeating pattern that is referred to as soil structure. Between the peds are cracks called “pores” through which soil air and water are conducted. Soil structure is most commonly described in terms of the shape of the individual peds that occur within a soil horizon.

Types of Soil Structure

Graphic Example	Description of Structure Shape
	**Granular** – roughly spherical, like grape nuts. Usually 1-10 mm in diameter. Most common in A horizons, where plant roots, microorganisms, and sticky products of organic matter decomposition bind soil grains into granular aggregates
	**Platy** – flat peds that lie horizontally in the soil. Platy structure can be found in A, B and C horizons. It commonly occurs in an A horizon as the result of compaction.
	**Blocky** – roughly cube-shaped, with more or less flat surfaces. If edges and corners remain sharp, we call it angular blocky. If they are rounded, we call it subangular blocky. Sizes commonly range from 5-50 mm across. Blocky structures are typical of B horizons, especially those with a high clay content. They form by repeated expansion and contraction of clay minerals.
	**Prismatic** – larger, vertically elongated blocks, often with five sides. Sizes are commonly 10-100mm across. Prismatic structures commonly occur in fragipans.
	**Columnar** – the units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded.

5. Soil Consistence

Soil consistence refers to the ease with which an individual ped can be crushed by the fingers. Soil consistence, and its description, depends on soil moisture content. Terms commonly used to describe consistence are:

Moist soil:

- loose – noncoherent when dry or moist; does not hold together in a mass
- friable – when moist, crushed easily under gentle pressure between thumb and forefinger and can be pressed together into a lump
- firm – when moist crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable

Wet soil:

- plastic – when wet, readily deformed by moderate pressure but can be pressed into a lump; will form a “wire” when rolled between thumb and forefinger
- sticky – when wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material

Dry Soil:

- soft – when dry, breaks into powder or individual grains under very slight pressure
- hard – when dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger

6. Bulk Density

Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume, and is commonly measured in units of grams per cubic centimeters (g/cc). Bulk density is an indicator of the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space: Pore space = 1 – bulk density/particle density. For example, at a bulk density of 1.60 g/cc, pore space equals 0.40 or 40%. At a bulk density of 1.06 g/cc, pore space equals 0.60 or 60%. The addition of even a small percentage of organic soil material to a mineral soil can affect the bulk density of that soil. Compare the two soil samples below:

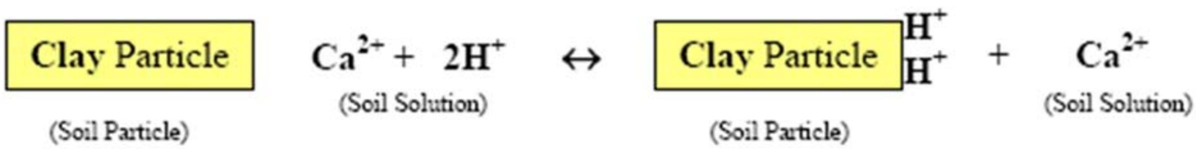
Soil “A”: 100% mineral soil material; bulk density = 1.33 g/cc
Soil “B”: 95% mineral soil material and 5% organic soil material; bulk density = 1.26 g/cc

The difference in bulk density relates to a difference in “particle density” of mineral soil material versus organic soil material. The average particle density of mineral soil material is 2.65 g/cc, which approximates the density of quartz. Conversely, the average particle density of organic soil material is 1.25 g/cc. Organic soil material weighs less than mineral soil material, so it will lower the bulk density of a mineral soil when added, as it reduces the overall weight of the soil.

CHEMICAL COMPONENTS OF SOIL

1. Cation Exchange Capacity (CEC)

Some plant nutrients and metals exist as positively charged ions, or “cations”, in the soil environment. Among the more common cations found in soils are hydrogen (H+), aluminum (Al+3), calcium (Ca+2), magnesium (Mg+2), and potassium (K+). Most heavy metals also exist as cations in the soil environment. Clay and organic matter particles are predominantly negatively charged (anions), and have the ability to hold cations from being “leached” or washed away. The adsorbed cations are subject to replacement by other cations in a rapid, reversible process called “cation exchange”.



Cations leaving the exchange sites enter the soil solution, where they can be taken up by plants, react with other soil constituents, or be carried away with drainage water.

The “cation exchange capacity”, or “CEC”, of a soil is a measurement of the magnitude of the negative charge per unit weight of soil, or the amount of cations a particular sample of soil can hold in an exchangeable form. The greater the clay and organic matter content, the greater the CEC should be, although different types of clay minerals and organic matter can vary in CEC.

Cation exchange is an important mechanism in soils for retaining and supplying plant nutrients, and for adsorbing contaminants. It plays an important role in wastewater treatment in soils. Sandy soils with a low CEC are generally unsuited for septic systems since they have little adsorptive ability and there is potential for groundwater.

2. Soil Reaction (pH)

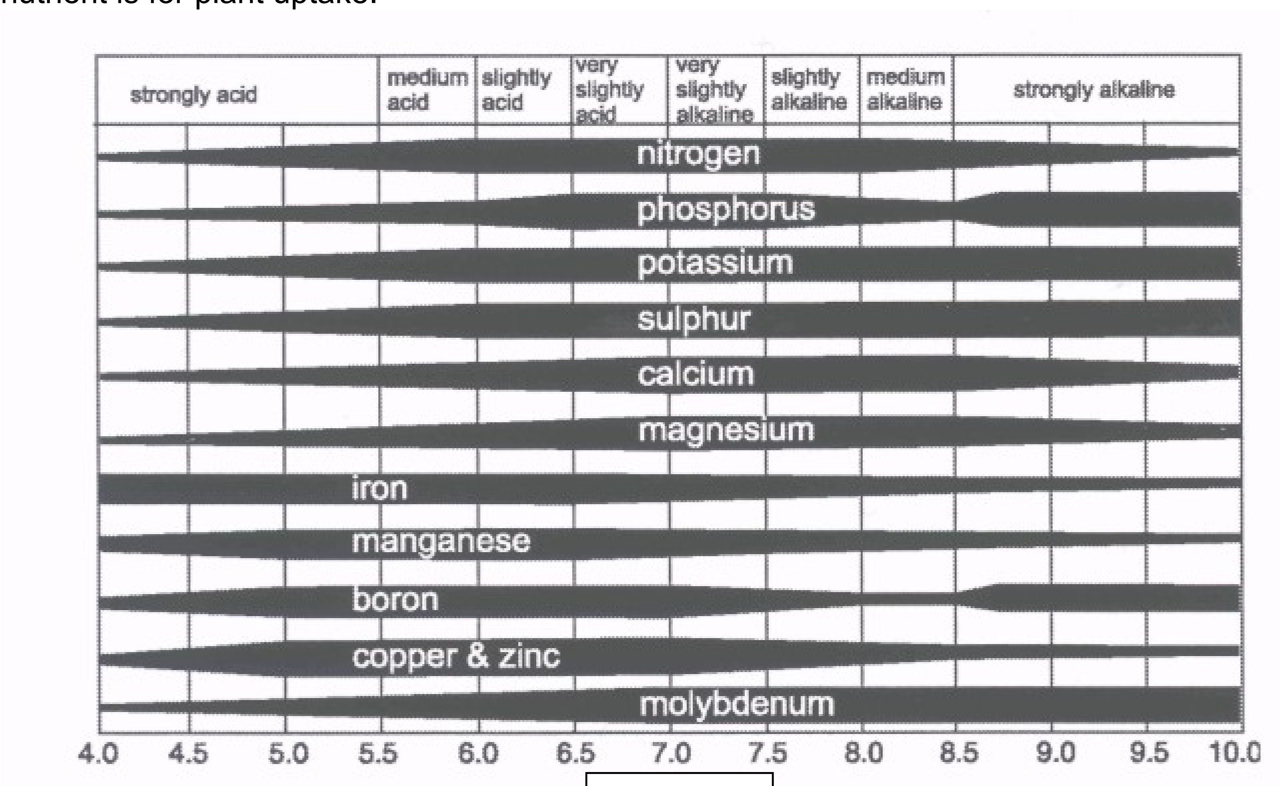
By definition, “pH” is a measure of the active hydrogen ion (H+) concentration. It is an indication of the acidity or alkalinity of a soil, and also known as “soil reaction”. The pH scale ranges from 0 to 14, with values below 7.0 acidic, and values above 7.0 alkaline. A pH value of 7 is considered neutral, where H+ and OH- are equal, both at a concentration of 10-7 moles/liter. A pH of 4.0 is ten times more acidic than a pH of 5.0.

The most important effect of pH in the soil is on ion solubility, which in turn affects microbial and plant growth. A pH range of 6.0 to 6.8 is ideal for most crops because it coincides with optimum solubility of the most important plant nutrients. Some minor elements (e.g., iron) and most heavy metals are more soluble at lower pH. This makes pH management important in controlling movement of heavy metals (and potential groundwater contamination) in soil.

In acid soils, hydrogen and aluminum are the dominant exchangeable cations. The latter is soluble under acid conditions, and its reactivity with water (hydrolysis) produces hydrogen ions. Calcium and magnesium are basic cations; as their amounts increase, the relative amount of acidic cations will decrease.

Factors that affect soil pH include parent material, vegetation, and climate. Some rocks and sediments produce soils that are more acidic than others: quartz-rich sandstone is acidic; limestone is alkaline. Some types of vegetation, particularly conifers, produce organic acids, which can contribute to lower soil pH values. In humid areas such as the eastern US, soils tend to become more acidic over time because rainfall washes away basic cations and replaces them with hydrogen. Addition of certain fertilizers to soil can also produce hydrogen ions. Liming the soil adds calcium, which replaces exchangeable and solution H+ and raises soil pH.
Lime requirement, or the amount of liming material needed to raise the soil pH to a certain level, increases with CEC. To decrease the soil pH, sulfur can be added, which produces sulfuric acid.

Soil pH can hinder or assist in the release of some soil nutrients. A chart below shows the availability of essential plant nutrients under certain pH levels. The wider the bar the more available that nutrient is to plants. The thinner the bar, the less available that nutrient is for plant uptake.



Soil pH

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Ethnic/Specialty Crops

SPECIALTY CROPS ON THE WORLD WIDE WEB

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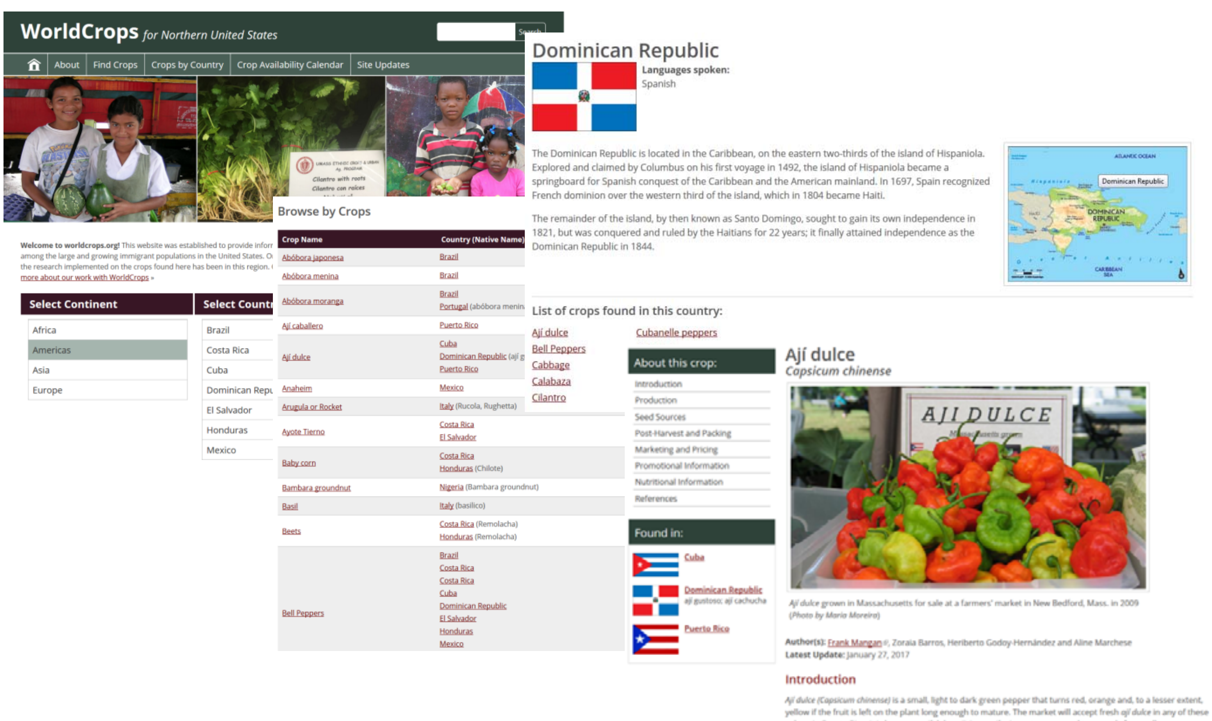
Reaching diverse ethnic consumers has been the focus of work over the past 20 years by a collaborative team of researchers and extension personnel from Rutgers, UMass, UFl, Cornell, and Penn State. One of the original projects of this Ethnic Produce Production and Marketing Working Group was the creation of the World Crops website (worldcrops.org) in 2004. Recently updated with a new vibrant graphic interface, the core mission of the World Crops website remains to give farmers in the Northeastern US a tool to explore the types of fresh produce sought by specific ethnic communities that may be potential customers and how to grow those types of vegetables and herbs.

To date, the site features 90 common and unusual food plant types that can be grown successfully in northern climates. Select a country for a brief summary of where it is located and its history along with a list of the vegetables and herbs consumed there. That crop list is then linked to fact sheets describing the plant, its production, post-harvest handling and marketing, as well as a list of related resources and references.

This presentation will give an overview of resources available on the World Crops website as well as a review of other resources on ethnic crop production available on the internet.



CROPS FOR LATINO MARKETS IN NORTHEASTERN US

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Introduction

Immigration has always been a source of U.S. population growth. Starting in the 1970s, the center of origin for the majority of U.S. immigrants has shifted from temperate Europe to tropical and subtropical regions of Latin America, Asia and Africa). In 2014, 42.4 million immigrants constituted 13.3% of the total U.S. population, the largest percentage in 100 years. This figure is projected to rise to 18.8% by 2060. More than 10 million immigrants and 8 million U.S. born children of immigrants live in the states of the Northeast Megalopolis, representing 33% of the total population of this region.

As has always been the case, the increasing populations of ethnic/immigrant groups in the United States have always created tremendous growth in the demand and sales of food products popular among specific ethnicities. Access to culturally appropriate foods for these immigrant groups represents opportunities for local farmers to grow specific crops for these markets. Many of the subtropical and tropical vegetables and herbs that are an integral part of traditional diets of these immigrant groups are not widely grown in the U.S. and are largely unknown to commercial farmers in the Northeast.
Despite their subtropical or tropical origins, many ethnic vegetable and herb crops are potentially adapted to production in the Northeast because of the region's high summer temperatures and long days. For example, more than 70% of the 35,000 acres of vegetables grown in Massachusetts are devoted to crops of subtropical or tropical origin (e.g. squashes, tomatoes, peppers, sweet corn, USDA Census, 2012).

Size and Importance of the Latino Population and Market in the United States

Latinos are the second largest race/ethnicity in the United States, after non-Hispanic whites, with 55 million people, up from 17 million in 1990, an increase of 320%. There are more Latinos living in the United States than any other of the 18 countries in Latin America, except Mexico. The per capita income of Latinos living in the United States is significantly higher than any country in Latin America, For example, the medium income per household of Latinos in living in the United States was $40,963 in 2013, while the medium household income in Mexico was $4,910 in 2012. The buying power of Latinos living in the United States is almost two trillion dollars. If all Latinos in the United States were their own county they would be the 11th largest economy in the world.

There are an estimated ten million Latinos in the Northeastern United States. Puerto Ricans, the second largest Latino ethnicity in the United States after Mexicans, are concentrated in the Northeastern United States where they are the largest Latino ethnicity in this region. The Puerto Rican migration to the US, including to the

Northeastern US, has increased dramatically recently due a severe economic crisis in this US territory and more recently due to Hurricane Maria which struck Puerto Rico in September of 2017. Dominicans are the second largest Latino ethnicity in the Northeastern United States and there are large and growing populations of Mexicans, Salvadorans and Guatemalans in this region. Like all immigrant groups that have come to the United States during its history, these immigrants desire fresh ingredients to prepare their traditional cuisines, which include specific fresh fruits and vegetables. Latinos, for example, represent 48% of total public school enrollment in the seven largest cities in Massachusetts (Figure 1).

Importance of Recognizing the Ethnicity of Target Latino Consumers

There are eighteen countries in the Americas where Spanish is at least one of the official languages. This does not include Puerto Rico, which has Commonwealth Status with the United States; Puerto Ricans are U.S. citizens. It is important to realize that in spite of the fact that people in these countries speak the same language, Spanish, there can be extreme differences among the food preferences from county to country, and even within a country there can be extreme differences from region to region. In Mexico, with the largest population in Spanish-speaking countries in the world, with more than 120 million people, the cuisine can change dramatically from one state to another. For example, Mexican cuisine is well-known for its use of hot peppers, the specific types of which can vary dramatically from region to region. However, do not assume that all Latino ethnicities in all Latino countries use hot peppers in their cuisine. Puerto Ricans and Dominicans, two of the largest Latino ethnicities in the Northeastern U.S., do not traditionally use hot peppers in their dishes. The two most popular peppers used by Puerto Ricans and Dominicans are *ají dulce* and Cubanelle peppers. The Scoville Units, used to measure the pungency of peppers, for both *ají dulce*, will measure around 1,500 Scoville units, compared to an average of 5,000 Scoville unites for jalapeno and over 250,000 for habanero.

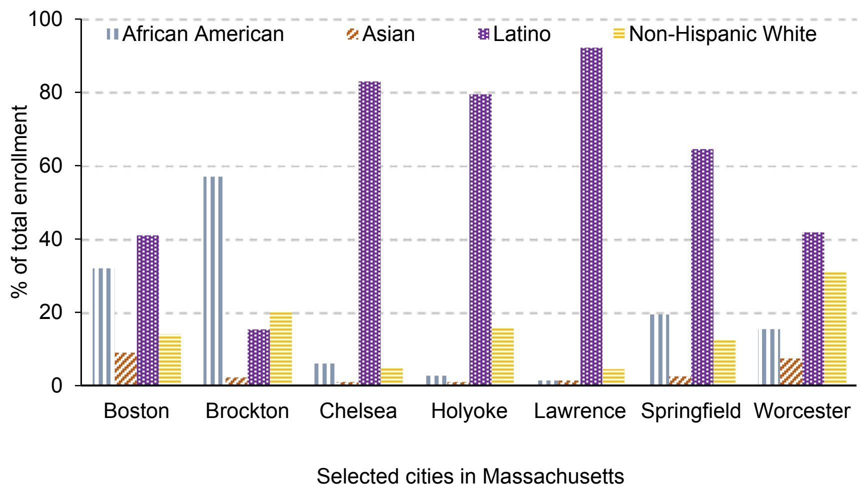


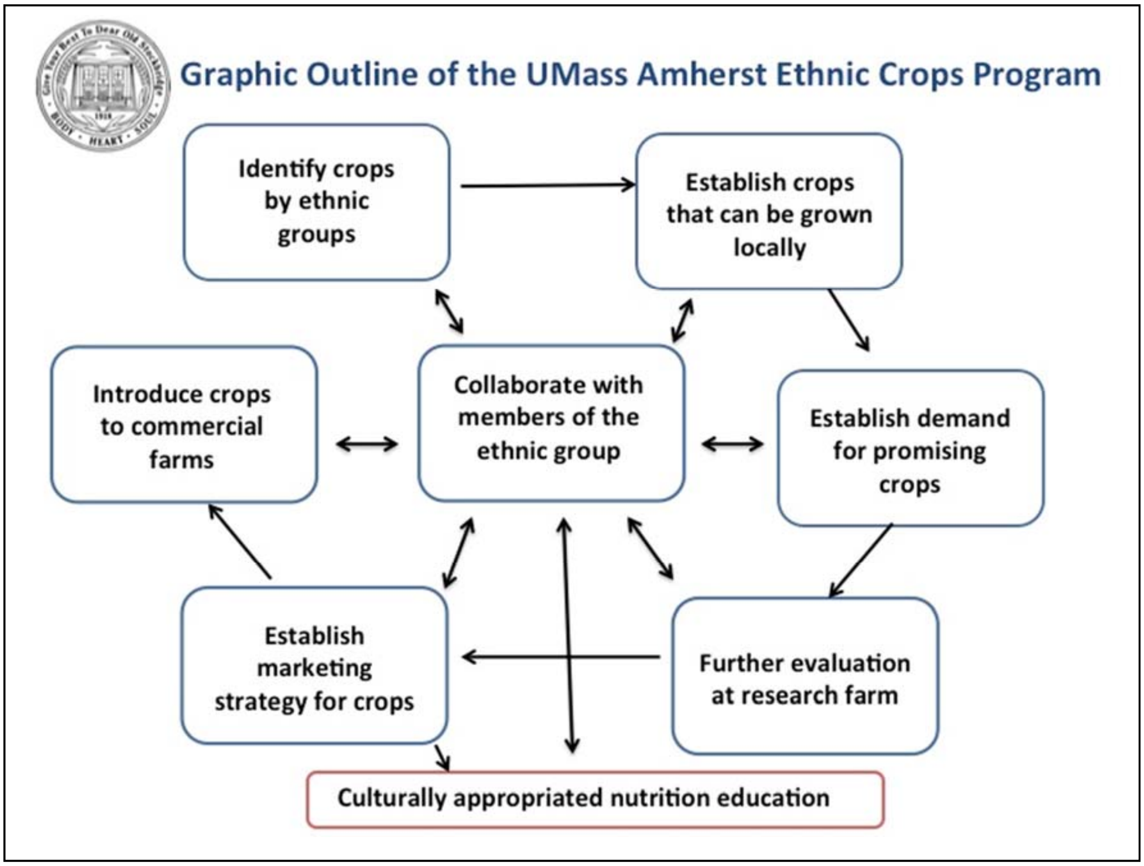
Figure 1: Percentage of students by race/ethnicity enrolled in select public schools in Massachusetts in 2016-17: Boston, Brockton, Chelsea, Holyoke, Lawrence, Springfield and Worcester. Source: Massachusetts Department of Public Education.

The UMass Ethnic Crops Program
At the University of Massachusetts Amherst, we have evaluated dozens of crops popular among immigrant groups for production and sales in New England since 2000. Over the years we have established a system used to choose the most successful crops to be grown and marketed by commercial farmers in New England. Figure 2 provides a flow chart representation of this system. Here are key steps of the process:

a. Collaborate with members of the target ethnic group. This has been an essential component to our work. Every immigrant community has leaders who speak the language and culture of the target ethnic group and can be important liaisons for farmers who want to grow and market crops popular among the specific ethnicity. We have worked with many of these community leaders in our work, including market managers, owners of small ethnic stores, chefs, health professionals and priests among many others. Usually it is someone that has been in the U.S. for a longer time than many others in his/her community and is in a better position to not only translate language but also culture.

These community leaders can provide a range of key information needed to be successful in growing and marketing crops popular by each ethnicity. We have used this input to promote crops using ethnic newspapers, radio, cable stations among other promotional venues.

b. Evaluate crops at the UMass Research Farm and in markets before recommending the specific crop for farmers to grow. One of the first steps in the process to evaluate a new crop is to grow it at our research farm. We want to understand how well the crop grows in our climate, days to harvest, insect and disease pressure, among many other essential components of crop growth. We also investigate the postharvest physiology of the crops we are working with, packing, storage, quality and shelf life. Once we know we can successfully grow a specific crop successfully at our research farm, we'll grow a larger amount in order to introduce it to markets that cater to the specific community.



We'll then work with the target markets to answer the following questions:

- How popular is the crop?
- What is the quantity that can be sold?
- What is the price point?
- What is the highest price the community is willing to spend?
- What are the best methods to promote the availability of this new crop to the target community?

By using this system, we have successfully introduced several new crops for commercial production in New England and other states and regions popular among many different ethnicities, including ones popular among Latinos. Examples include *chipilín* (*Crotalaria* spp.*)*, *calabaza* (*Cucurbita* spp.) and *ají dulce (Capsicum chinense)*. Detailed information on these and other crops is available at www.worldcrops.org.

c. Research-based information on how to grow, pack and market new crops popular among immigrant and ethnic groups

When we are confident that there is an opportunity to produce a new crop in New England, we put this research-based information on www.worldcrops.org, a website started with funding from the USDA SARE program. Our goal for the information on this site is to provide commercial farmers all the information they need in order to both grow and market these crops successfully. In many cases we bring the reader to the New England Vegetable Management Guide (https://nevegetable.org/) when the crop is the same genus and sometimes species of the “ethnic” crop on this site.

We have organized this site according to countries in the world. One reason for this organizational structure is that many ethnic groups are concentrated in specific cities or neighborhoods. For example, Holyoke Massachusetts has the largest Puerto Rican population as a percentage of any city in the United States. In this case, a grower who wants to grow and market crops for the Latino population in Holyoke would want to check out the crops under "Puerto Rico" on www.worldcrops.org.

EXOTIC CROPS IN NJ AND THE MID-ATLANTIC*

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Introduction: Exotic (or Ethnic) crops present new opportunities for growers, produce marketers and consumers in NJ and the Mid-Atlantic. The rapidly changing demographics compels a new look at the crop content of the region with a focus on responding to crop preferences of rising ethnic nationalities in the region. This presentation highlights current efforts at Rutgers University on promoting exotic peppers, amaranths, okra, roselle and tigernuts as additions to the bread basket of NJ and the mid-Atlantic communities to fulfill our land grant responsibilities.

Why Exotic Crops Research and Development at Rutgers? We are a Land Grant University with responsibility to respond to community needs in Production Agriculture and Food. Demographic changes in recent decades compel us to respond to the shifting population and associated cultural preferences for food crops. New Jersey environment will support the production of many of the ethnic crops in the diet of the major ethnic groups that are increasing in population in our state and region. If we can produce the crops here, we can enhance food security in our state and region, and add significant value to our economy.

Ethnic Diversity in NJ (US Census 2016 https://www.census.gov/quickfacts/NJ): NJ is the 3rd most ethnically diverse state in the United States after California and New York: White non Hispanic – 56.8%; Hispanic Latino ---- 20%; Black/African American --- 15%; Asian --- 9.8%. The most rapidly growing ethnic groups are the Hispanic/Latino and Asian groups

Ethnic Diversity in Middlesex County, NJ (New York Times 2011: http://www.nytimes.com/2011/02/04/nyregion/04jersey.html?mcubz=0): Sub-Urban Middlesex County has the highest ethnic growth in NJ in recent times. Asian population growth is heaviest in Edison, Piscataway, Woodbridge and East Brunswick. The number of Asians in the county jumped more than 50 percent, and by 2010 accounted for 21.3% of the population. In Edison, Asians reached 43.1 percent of the population, surpassing whites as the largest group. In places that were already majority Hispanic in 2000, like

Perth Amboy, Passaic, North Bergen and Paterson, their predominance increased markedly. Hispanics became a majority in Elizabeth and nearly did in New Brunswick Hispanics overtook blacks as the largest group in Camden; and they passed whites as the largest group in Hackensack.

Our Exotic Crop Research Focus at Rutgers University: In 2001 we formed an Ethnic Crop Research Group, with Dr. Ramu Govindasamy, Professor of Ag & Food Resource Economics, as Leader. Our team reached out to ethnic crop research scientists at U-Mass, MA and UFL, FL to form an East Coast United States Consortium. Between 2002 and 2013, the Consortium wrote research proposals and received ~$2 million grant money from USDA to analyze and characterize the Ethnic Crop industry on East Coast United States**.** The Consortium focused on four major ethnic groups: Chinese, Indians, Mexicans, Puerto Ricans**.** Our work identified the major ethnic crops preferred by each of the ethnic groups considered and selected the top 10 crops for each group based on crop quantity purchased per family from ethnic markets on East Coast United States**.** We are now investigating the production potential of some of the ethnic crops identified in our study in New Jersey and East Coast United States

My Exotic Crop Research & Development Work at Rutgers University:
Vision: Crop diversification for food security in a rapidly changing demographic in NJ
Mission: Increase exotic crop content of the food basket of NJ to advance the Land Grant Mission of Rutgers, The State University of New Jersey
Current Focus Crops: Exotic Peppers (Capsicum spp), Okra (*Abelmoschus spp*), Roselle *Hibiscus spp*.), Amaranths (*Amaranthus spp*.), and Tigernuts (*Cyperus esculentus* var. *sativu*s)
The Major Research Questions: Can these Exotic crops be produced in NJ? What are the Market Opportunities?

Exotic Peppers: Exotic peppers (*Capsicum* spp.) are common in the diets of all ethnic cultures that increasingly inhabit NJ and the Mid-Atlantic. Since 2009, I have worked (and continue to work) with Dr. Tom Orton (Vegetable Breeder) and later with Dr. Jim Simon (Natural Plant Product specialist) to develop exotic peppers (*Capsicum annuum, C. chinense,* and *C. frutescense)* for the fresh and processing markets. Starting in 2010 with 45 pepper selections, we conducted field and greenhouse experiments across the state in NJAES research stations at Rutgers Ag Research and Extension Center (RAREC) in Upper Deerfield, Horticultural Research Farm III in New Brunswick; and the Snyder Farm in Pittstown to confirm the adaptation of the selections in our germplasm repository. Since 2010 we have selected for those that can be grown successfully in New Jersey and in April 2017 we released to the public the Rutgers Pumpkin™ Habanero, a mild (<50,000 SHU) flavorful habanero with no heat in the flesh, tangerine taste and attractive miniature pumpkin shape (Figure 1). Color varies from yellow to orange and red. Rutgers Pumpkin™ Habanero is a natural cross between the African and Mexican habaneros in our germplasm. Other habanero and jalapeno selections are in the pipeline for release in 2018, 2019 and beyond.

Okra: Okra (*Abelmoschus* spp.) is a vegetable crop of African and Asian cultures. At Rutgers, we have conducted field and greenhouse studies on the African and Asian selections since 2011. The African okra (*A. caillei*) produces red stem and short bulky red fruit while the Asian okra (*A. esculentus*) produces green stem and long slim green fruit. In our studies, a natural crossing between the two has produced a third okra type that combines the red color of the African type with the long slim fruit of the Asian type (Figure 2). The third okra type is temporarily named the "American" okra. The "American" okra has variegated (red/green) stem and long slim red/green fruit; it is taller than the African and Asian okra, and flowers 3-5 days earlier. Yield is comparable to the African and Asian okra but the variegated (red/green) color adds a special value to the plant. Work is in progress on the phytochemical profile of the three okra types.

Roselle: Roselle, also popularly known as sour-sour or sorrel, is a major ethnic vegetable associated with African, Asian and Caribbean cultures and culinary. The Asians eat the leaf as spinach while Africans and the Caribbeans use the calyx and flowers in various preparations including beverage, tea and other traditional uses. Germany is a key importer of the dried flower and calyx from Thailand, China and the Sudan. Some southern states in the US have started importing roselle flower and calyx for herbal tea. We started studying roselle at Rutgers in 2010. We began with five selections and currently focus on three that have significant market opportunities in New Jersey, namely: the Indian Red/Red (IRR), Indian Red/Variegated (IRV) and the African Green (AG) (Figure 3). Leafy green from the three selections is in high demand in Indian groceries. Our economic analyses so far shows that roselle can be a profitable crop to grow in New Jersey for the leaf. The roselle selections we currently work with are short day cultivars and cannot complete their life cycle in the field before the frost in October/November. However, these cultivars flower in the greenhouse in September and produce fully mature fruit by early to mid-December. We recommend this crop to our growers. They are easy to grow, require minimal management attention and high yielding. Demand for the leaf is growing in the Asian communities.

Amaranths: Vegetable amaranths belong to the same family of plants commonly known in the United States as pigweed --- a dreaded weed of field and vegetable crops. These vegetable crops are common throughout the tropical world spanning the African, American and Asian continents. At Rutgers University, in addition to responding to demographic necessities, we are interested in integrating amaranths into our vegetable stream, primarily as a filler for spinach during the warm months of the year when spinach is off-season and very expensive in the market. Amaranths thrive during the warm months of the year, they are used the same way as spinach and the two vegetables complement each other reasonably well in their nutrient profiles. In our research which started in 2005, we have identified a few amaranth selections with high capacity for leaf and grain production (Figure 4). Several ethnic grocery stores in New Brunswick will buy amaranths for retail sale to their customers. Amaranths are easy to grow. Insect damage may be a major challenge under some environmental conditions, but the common insect problems may be controlled using common IPM strategies along with some organic and/or synthetic insecticides as and when necessary.

Tigernuts: Tigernuts (*Cyperus esculentus* var. *sativus*), also popularly known as chuffa, is little known in the United States but much better known in Africa and more recently Spain. Tigernut is a close relative of yellow nutsedge, one of our most difficult weeds to control in field and vegetable crops. Unlike the weedy yellow nutsedge, tigernuts produces edible underground tubers with delicious chewy taste and high-energy content. The tuber is gluten free and produces an oil quality of the same grade as olive oil. At Rutgers University, we have been studying tigernuts since 2006 primarily to understand the growth habit and the production potential under NJ conditions. Tigernuts grows well under NJ conditions but has no tolerance for freezing temperature. Repeated cultivation in our research farms has shown that it has no capacity to survive the winter months and therefore poses no threat to the ecological balance of our cropping systems, especially where the weedy yellow nutsedge may be prevalent. From nine tigernut selections we have evaluated so far, three are being investigated, out of which one will be identified as the "Rutgers Golden Tuber™" in 2018 for release to the public.

Conclusions: Since 2001, our Ethnic Crop Research team at Rutgers University in collaboration with colleagues at the University of Florida and the University of Massachusetts has advanced the knowledge of exotic crops on East Coast United States. We are at a point where we can safely identify some of the key exotic crops with significant economic prospects for enhancing our Agricultural economy as we respond to the needs of our dynamic and fast changing communities**.** In my research, I have focused on the agronomy of some of these exotic crops and the market opportunities. So far, I have determined that many of these crops may be grown successfully in NJ and the market is substantial for growers to explore. It is our desire to share information with growers, marketers and consumers on our experiences and how we can work together to add value to our food security through sustainable production of those exotic crops our communities need to support a strong and healthy workforce.

Figure 1: Pumpkin Habanero: Released to the Public on April 29, 2017

Figure 2: Major okra types in our R&D

African Green Indian Red

Figure 3: Roselle types: Relative heights in the field

Figure 4: Red Leaf Amaranth in the field (Left) and in the greenhouse (Right)

Figure 5: Tigernut growth habit in the greenhouse (left) and tuber shapes (right)

Tomato

REVIEW OF TOMATO DISEASES AND SUCCESSFUL MANAGEMENT STRATEGIES FOR THE 2018 SEASON

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Tomato diseases such as Septoria leaf spot, Early blight, Late blight and White mold can cause serious problems in field and high tunnel tomato production. It is important to remember that disease development is driven by environmental conditions. Relative humidity (RH), air temperature, soil temperature and leaf wetness will greatly influence disease development in the field and high tunnels.

Septoria leaf spot will only infect the foliage and stems of the tomato plant. Symptoms to scout for are small, circular lesions with a dark outer edge and brownish-tan center. Black spore-producing bodies will develop in the center of these lesions. When scouting, look on the lower foliage of the tomato plant early in the season. The disease will cause premature defoliation, and left uncontrolled can cause 100% defoliation.

Early blight will affect the foliage, stems and fruit. Early blight will produce brown, concentric lesions on the foliage and stems and are much larger than lesions produced by Septoria leaf spot. Early blight, like Septoria leaf spot, can also cause premature defoliation. Early blight can also infect green and red fruit through the stem attachment. Lesions that develop on the fruit also produce brown, concentric rings.

Although Anthracnose fruit rot can infect green fruit and foliage, symptoms only appear on ripe fruit during the growing season. Anthracnose lesions begin as slightly depressed circular lesions. As lesions enlarge they become more flat and develop black, speck-like fruiting bodies in the center of the lesion.

Control of all three diseases should begin with a weekly regular fungicide maintenance program with the alternation of chemistries with different modes of action (i.e., from different FRAC codes). Field grown tomatoes in higher elevations (i.e., north Jersey), that are not rotated away from tomatoes, and in late planted fields, should be sprayed shortly after transplanting. In all other areas, begin sprays when crown fruit reach one-third their final size. This can include chlorothalonil or manzate fungicide alternated with a strobilurin (Quadris, Flint or Cabrio which are FRAC group 11 fungicides). Strobilurin fungicides have a maximum-season usage and should not be mixed together in a single application or used in back-to-back applications by itself or together. The alternation of fungicide chemistries helps to reduce the potential for the build-up of fungicide resistance.

Remember that any fungicide maintenance program should begin with scouting and identifying the disease. Scouting on a regular basis will help growers stay on top of potential problems and may reduce the high cost of fungicide use. Always remember to read the pesticide label before using any product.

Bacterial diseases of tomato such as canker, leaf spot, and speck can cause serious losses in tomato crops if left uncontrolled. All three bacterial diseases of tomato can be seed-borne and great care should be taken in planting certified, disease-free seed and/or treating seed prior to seeding with Clorox or hot water seed treatment. These bacterial diseases can start in the greenhouse during seedling production and be carried into the field. Cultural practices in the greenhouse such as keeping greenhouse space free of weed species and proper sanitary practices can be used to help reduce the chances for bacterial disease development. Symptoms of Bacterial canker on infected leaves include marginal leaf necrosis and dieback. On fruit, Bacterial canker causes distinct 'bird's eye spots' on green and red fruit which appear as a small, raised, scabby, circular spot with a white margin. Symptoms of Bacterial speck (*Pseudomonas syringae* pv. *tomato*) on infected leaves include small, blackish-brown lesions with an irregular chlorosis (yellowing). On infected fruit, Bacterial speck causes a distinct, pin-point black lesion. Symptoms of Bacterial spot (*Xanthomanos campestris* pv. *vesicatoria)* on infected leaves include small, blackish-brown circular lesions which produce a chlorotic (yellow) 'halo'. On infected fruit, Bacterial spot produces large brown, raised, circular, scabby lesions which are distinctly different from Bacterial speck lesions. In the case of both Spot and Speck, heavily infected foliage will cause premature defoliation leading to potential sunscald and fruit infections if left uncontrolled. Regular applications of copper containing compounds can help suppress bacterial infections. If infected plants are suspected in the greenhouse or the field great care should be taken to help reduce the chances of spreading all three diseases. For example, plants that are suspect to bacterial infections should be removed and destroyed. In the field, rotate between fields to avoid a carryover of disease on volunteers and crop residue. Maintain proper weed control and remove any plants suspected with disease. Avoid working in fields when foliage is wet because harvesting, pruning and tying can spread bacterial diseases. Disinfest all stakes and equipment prior to and after use.

Late blight (*Phytophthora infestans*) is an important disease of fresh-market and processing tomato and potato in the Northeast. In recent years the pathogen has been active throughout the region. The pathogen, *Phytophthora infestans*, is an oomycete, or water mold, with free-water favoring its development and spread. Cool, wet weather with high relative humidity is ideal for its development. Left uncontrolled, Late blight can spread swiftly from plant to plant and field to field. Late blight survives between seasons on infected plant material left in the production field, in cull piles, and in homeowner's gardens. The fungus can infect all aboveground parts of the tomato plant causing circular, water-soaked lesions on leaves. Gray to white 'fuzzy' growth develops on the margins of leaf lesions which produce masses of sporangia that are spread during rainfall. Infections in fruit often begin when green fruit are maturing. On green fruit, dark, blackish-brown lesions remain firm as lesions expand. Control of Late blight begins with removing sources of potential inoculum, such as plant material left in the field and cull piles. Plant material should be disked under thoroughly or buried. Preventative fungicide programs should be followed during the growing season to help reduce the chances for infection. Fields should be monitored and scouted on a weekly basis. If Late blight has been diagnosed in surrounding areas fungicide applications need to be adjusted accordingly. Growers can follow Late blight outbreaks and reports in the US at https://usablight.org/.

BREEDING AND RELEASE OF SPECIALTY GRAPE AND PEAR TOMATOES WITH NOVEL COLOR, FRUIT FIRMNESS, AND HIGH FLAVOR

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The market for grape tomatoes has rapidly expanded since their introduction in the 1990s. Originally, the only cultivar being sold was ‘Santa’ red grape tomato, creating a unique and consistent product for consumers. There are now numerous cultivars of red grape tomatoes on the market which have varying fruit quality and flavor profiles. A breeding program was initiated to develop new high quality grape tomatoes for local growers.

The initial focus of the breeding program was to take advantage of the exceptional flavor profile of a hybrid cultivar of red grape tomato that was subsequently withdrawn from the market by a seed company, referred to as “Hybrid X” since the cultivar is under negotiation and cannot be disclosed by the trademarked name. Seed from fruit of Hybrid X were planted creating a segregating population of red grape tomato seedlings. The tomato seedlings with the best field performance, fruit quality and flavor were then selected and self-pollinated over several generations to create uniform inbred lines.

During the same period of time that the red grape tomato lines were being developed, bicolor (yellow fruit with a red blush) grape and pear tomatoes were discovered in a plot of what was supposed to be a bicolor cherry tomato cultivar. These bicolor grape and pear fruit types were selected because they were unique then self-pollinated to create uniform lines. The resulting bicolor grape and pear tomato lines were then crossed with the red grape lines creating a variety of fruit shapes, colors and sizes (Figure 1.) Several bicolor fruit types were selected from that variants for further testing (Figure 2.).

In 2017, inbreds and hybrids of advanced selections of bicolor grape tomato types were established at Snyder Farm for continued evaluation and selection. The tomato plants were grown using typical commercial production methods and trellised using a stake and weave system on 8’ stakes. Plants were evaluated and fruit were harvested and tested in the lab at the Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. (Table 1.)

The result of this work has been the development of a tomato selection (25.1c) with an indeterminate plant type, that produces large numbers of bicolor (yellow fruit with a red blush) grape shaped firm fruit with good flavor. This grape tomato selection will be made available for limited grower trials. This selection should be of interest to growers looking for a productive specialty cultivar with good flavor that is identifiable in the market by its unique color.

Figure 1. Variation in grape and pear tomato fruit color and shape from the breeding nursery

Figure 2. Bicolor grape tomato fruit selections from the range of variation in Figure 1. Selection 25.1 types are shown on the left.

Table 1. Fruit characteristics of grape tomato selections

Selection/ Cultivar	Fruit color & shape	Date	[1]Fruit weight (g)	[2]Firmness	[3]External color	[4]pH	[5]Brix
03.2a	Yellow blush grape	14-Sep	12.76	3	3	4.26	6.0
03.2b	Yellow blush pear	14-Sep	15.84	3.5	3.5	4.39	6.2
25.1a	Bicolor grape	14-Sep	11.17	3	3.5	4.08	5.6
25.1a x 03.2	Bicolor grape/pear	29-Sep	10.50	3.5	3.5	4.16	6.6
25.1b	Bicolor grape	14-Sep	11.08	3.5	3	4.15	6.2
25.1c	Bicolor grape	14-Sep	11.88	3.5	3.5	4.14	6.4
25.1c -1	Bicolor grape	29-Sep	8.80	3.5	4	4.01	6.6
25.1c – 2	Bicolor grape	29-Sep	10.65	3	5	4.17	6.2
25.1c – 3	Bicolor grape	29-Sep	10.50	3.5	4	4.15	6.4
25.1c – 4	Bicolor grape	29-Sep	10.10	3	5	4.15	6.4
25.1c – 5	Bicolor grape	29-Sep	9.81	3	5	4.17	6.2
25.1c – 6	Bicolor grape	29-Sep	11.40	3.5	4	4.28	6.4
Isis Candy'	Bicolor cherry	14-Sep	18.25	2.5	4	4.35	6.4
Smarty'	Red grape	14-Sep	9.38	4	5	4.50	6.8
Hybrid X	Red grape	14-Sep	10.44	3.5	5	4.16	6.6

[1]Average fruit weight in grams; [2]Firmness: 1=most soft; 5=most firm
[3]Exterior Color: 1=least red/orange; 5=most red/orange
[4] pH from composite locular filtrate of 20 fruit; [5]Brix from composite locular filtrate of 20 fruit

Preliminary results have been obtained with the qualitative and qualitative characterization of fruit volatiles that indicate a favorable flavor profile for the 25.1c selection as compared to large-fruited and other small-fruited tomato cultivars. These results were not completed in time for the proceedings paper, be will be presented at the meeting in February.

Farm Brewery Crops (pm)

BARLEY MALT QUALITY CONSIDERATIONS FOR THE BREWING INDUSTRY

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Craft brewing has undergone tremendous growth over the past ten years with brewery numbers increasing form slightly under 1,500 in 2007 to over 5,200 today (Brewers Association, https://www.brewersassociation.org/statistics/number-of-breweries/). Concomitant with the rise of craft beer, has been an increased interest in brewery crops: hops, barley and other grains. This has been especially apparent with hops, and the predominance of hop-forward and single-hop beers in the market. Interest barley has recently followed, and is being driven by craft malting and the demand for local ingredients. Craft maltsters are independent, utilize local grain, and generally produce less than 10,000 metric tons of malt per year. Today there are around 100 craft maltsters in operation or planning across the US. As a result, there is now an increased interest in barley cultivation in non-traditional areas, as well as regions that have not produced malting barley for many years.

An understanding of barley and malt quality is extremely important for the success of the local grain, malt and beer production. All individuals in the barley- to beer- chain can have a profound impact on quality, as does the environment. It is very important for the maltster to understand not only the brewer’s needs, but also the limitations of the farmer. Likewise, it is important for the farmer to understand the requirements of the maltster. A general understanding of malt quality parameters requires some knowledge of the malting and brewing processes.

At the simplest level, malting is essentially a controlled germination process, in which grain is converted into a form which more suitable for brewing. As such, it is absolutely paramount that malting grains germinate, and malting barley is perhaps the only grain that must be delivered in a living state. Malting consists of three phases including steeping (soaking in water) to bring kernels to 42-45% moisture, germination under cool, humid conditions, and kilning (drying) to end the malting process, but also develop flavors and color. During the malting process, enzymes are produced that break down endosperm cell walls and proteins (American Malting Barley Association, http://ambainc.org/media/AMBA_PDFs/Pubs/Production/Quality_Brochure.pdf). It is critical that conversion or ‘modification’ of these seed reserves take place in a balanced and uniform manner. Kilning suspends the enzymatic processes, but when malt is mixed with water in brewing, the processes continue. During the brewing process, around 80% of the barley grain is extracted (or dissolved in water). The major reaction in brewing is the conversion of starch to fermentable sugars, and this is the main contributor to malt extract'. The amount of malted barley that is 'extracted' is critical to the brewer and is related to the quality of the malting barley and how that barley is malted. Overall, the malt extract not only contributes fermentable sugars, but also plays a key role in beer body, foam, and flavor. Each kernel in a batch of malt should be modified to the same extent, as uneven malt modification will result in processing problems in the brewery. These include poor filtration, haze, poor yeast growth, and off-flavors.

Barley and malt quality requirements significantly differ between brewers using rice or corn adjuncts and those utilizing 100% malt. Craft brewers typically produce all-malt beers. Until recently, North American malt barley breeding programs focused on the development of barley for adjunct-type beers. With publication of guidelines for 100% malt beers by the American Malting Barley Association (http://ambainc.org/media/AMBA_PDFs/Pubs/Malting_Barley_Breeding_Guidelines_April_2017.pdf) and the Brewers Association (https://www.brewersassociation.org/best-practices/malt/malting-barley-characteristics/) breeders are now directing efforts to the needs of the craft segment. A brief list of quality parameters is presented below:

Malt Barley Quality Requirements

Germination: The percentage of kernels germinating must be at least 95%. Kernels that don't germinate vigorously can contribute to mold growth during malting and lead to problems associated with uneven germination and malt modification, such as reduced extract and poor filtration.

Moisture: Malting barley should be stored at 13.0% moisture or less with good air circulation. Inadequate storage conditions can lead to rapid loss of germination and insect and mold problems. This is a frequent cause of problems with new grain growers.

Kernel Plumpness: Plump barley kernels contain higher levels of starch and lower amounts of husk resulting in a higher percentage of extract. Thin barley kernels generally have higher protein levels, and if not removed prior to malting, can cause uneven modification.

Skinned and Broken Kernels: The loss of portions of the barley husk has a dramatic effect on the malting process, and can be affected by combining and grain handling. The husk regulates water uptake into the kernel and the loss of part of the hull leads to uneven modification. The husk is also important in protecting the shoot during germination. If unprotected, it can easily break-off ending the malting process for that kernel.

Protein: A moderate amount of grain protein is needed for good yeast nutrition, the development of desired enzyme levels and foam stability. High protein in barley slows water uptake during malting and lowers the ability of the kernel to modify completely. If the protein is too high the amount of extract available to convert to beer will be reduced and beer hazes could form. Blending of malting barley lots to meet protein or other quality specifications impacts processing. Kernels with low protein in such a blend will absorb water more rapidly than those with high protein and result in malt that is unevenly modified. Protein levels for craft beers should be <12%, but limits depend upon the brewer. Levels as low as 10% may be requested.

Sprouted Barley: Rainfall prior to harvest can result in the pre-harvest sprouting or pre-germination of barley kernels. The presence of sprouted kernels reduces the ability and/or rate of germination during malting. Barley that has some sprout damage prior to harvest may or may not germinate again, but even if it does, it is at greater risk to unexpectedly lose germination potential upon storage. Sprouting is a problem in many of the 'new' barley growing areas.

Fusarium Head Blight (Scab): FHB is a fungal disease that attacks barley, wheat and other small grains. The fungus enters the kernel, releasing enzymes that begin to breakdown starch and protein. In addition, Fusarium produces deoxynivalenol (DON), a mycotoxin that makes the grain unsuitable for malting and brewing because of food safety concerns. The fungus also produces other compounds that cause packaged beer to 'gush'. FHB can be an occasional problem in both traditional and new barley areas.

Malt Quality Requirements

Extract: Malt extract is the percentage of the grain that is extracted in brewing. It is of extreme economic importance for larger brewers, as it controls the amount of malt needed to produce a given lot of beer. Extract is influenced by variety, the malting process, and the growing environment. Values for most modern varieties are around 82%, while those for heritage varieties are often around 75%. The value for extract is key for formulation by any brewer.

Soluble Protein: During malting the endosperm protein is broken-down to a mix of soluble protein/peptide and amino acid. The value for soluble protein reflects the percentage of the malt that is present as nitrogen (x 6.25) in the malt extract. Some protein is needed to support yeast growth and foam. Higher amounts are needed by adjunct brewers, as corn or rice provide no soluble nitrogen. Excess SP can cause problems with reduced extract and increased beer color. Craft brewers generally require lower soluble protein and free amino nitrogen (FAN) levels than adjunct brewers.

Alpha-Amylase: Alpha-amylase is an important malt enzyme for the reduction of starch viscosity, and providing substrate for DP. Adjunct brewers frequently require high alpha-activity (>50 DU), but the need of craft brewers is less.

Diastatic Power: DP is an archaic term (but still used) that describes the malts ability to degrade starch to fermentable sugars during brewing. While reflecting the activity of several enzymes, it is largely a measure of beta-amylase. DP requirements for all-malt brewers generally do not exceed 150 ASBC units, while those for adjunct brewers are higher.

Beta-Glucan: Beta-glucans are cell-wall carbohydrates that surround the starch and protein in the barley endosperm. Their breakdown is key in the modification of barley during germination. If inadequately degraded, the beta-glucans can cause lautering and filtration problems in brewing. Desired values are < 100 ppm in the malt extract. On the contrary, beta-glucans are an important component of dietary fiber in barley and oats, and are believed to be associated with the reduction of cholesterol levels (i.e. a good food barley is not a good malting barley).

Flavor: Barley and malt flavor have not traditionally been a specification that was directly assessed during the development the barley varieties. However, several methods for assessing flavor have recently been developed (ASBC Hot Steep Malt Sensory Method, http://blog.brewingwithbriess.com/wp-content/uploads/2017/05/Briess_WortSensory_ASBCHotSteepMethod.pdf). Flavor is influenced by barley variety, growing environment, and malting conditions.

PRODUCTION PRACTICES FOR GROWING QUALITY MALTING BARLEY

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The craft malting and brewing industries across the US have an increased desire to use locally produced grains for making their products. Barley used for malting and brewing must meet specific requirements on nearly 20 different end-use quality traits. Barley grown outside of its area of adaptation often fails to meet the specifications needed for malting and brewing, which include grain free of pre-harvest sprouting, grain protein less than 12%, plump kernels > 80%, and germination ≥ 95%. Additionally, unadapted varieties often have lower yields and are susceptible to local diseases that are not present in the area where they were developed. This talk will focus on production practices and choices the producer can make to increase their likelihood in producing high quality malting barley. Topics to be covered include determining the growth stage of barley, fertilizing requirements for malting barley, variety selection, and recommended seeding rates.

Growth Stages

Before the effects of different production practices and environmental stresses on the performance of barley can be understood, knowledge of the different growth stages and yield components of barley are needed. Different scales are available for describing the growth of barley, including the Feekes, Haun, and Zadoks growth stage scales. Components that determine yield in barley are the number of spikes per area, the number of kernels per spike, and kernel weight. Stresses during a certain period of the growing season will reduce one or more of the yield components. Factors affecting the number of spikes per area include those that directly affect the number of plants per area and the number of tillers per plant. Plant and tiller number can be impacted most severely from planting to shortly before the jointing stage. Factors that can reduce the number of plants per area include planting rate, insufficient moisture for germination, water-logged soils following planting that may kill the seed or cause soil crusting, winter-kill, weed competition, insects, and diseases. Excessive temperatures, insufficient moisture, insects, and weed competition can negatively impact the number of tillers per plant.

Before jointing, the developing barley plant is tolerant to freezing temperatures because the growing point is protected below the ground. At the jointing stage the growing point of the barley plant comes above ground and is vulnerable to environmental stresses that will cause fewer spikelets per spike. The number of kernels per spike also can be impacted by stresses during pollination, such as freezing or excessive temperatures that can kill the pollen. Pollination in barley generally occurs during the late-boot stage.

Stresses following fertilization will affect kernel weight and plumpness, possibly reducing grain quality. These stresses include excessive temperatures, insufficient moisture, weed competition, diseases, and insects. Damage to the flag leaf and the leaf below it by insects or diseases more severely impacts kernel weight than damage to the lower leaves. Thus, growers are encouraged to scout their crop to make sure that the top two leaves of the plant are free from damage caused by disease and insects.   Thin and lightweight kernels are undesirable for malting because they typically are high in grain protein and are difficult to malt uniformly. The resultant malt generally has overall poor-quality malt, and especially low malt extract.

Plant Nutrition

Barley responds well to fertilizers containing nutrients limiting in the soil, especially nitrogen. Additional amounts of nitrogen fertilizer can be applied to increase grain yield and protein content when soil nitrogen is limiting. The amount of fertilizer to apply is dependent on the end use of the harvested grain, soil test results, and expected yield. For barley used in the craft malting and brewing industries, grain protein below 11.5% is desired. Higher protein can cause production issues during malting and brewing.

The amount of nutrients needed to produce a satisfactory barley crop can be determined from a soil test, which is a reliable indicator of the amount of residual nutrients in a soil profile (https://www.ag.ndsu.edu/publications/crops/fertilizing-malting-and-feed-barley). Higher levels of nitrogen fertilizer are recommended for barley produced for non-malting uses; however, excessive nitrogen can result in a lush crop that is prone to lodging and foliar diseases. Also, excessive fertilizer can be environmentally problematic in well-drained soils or areas with a high-water table if they leach into the groundwater.

Accurate estimates of a yield goal are extremely important in choosing the proper amount of nitrogen fertilizer to apply. Application of too much nitrogen fertilizer can result in the barley having excessive protein and being rejected for malting. In environments and/or years where moisture is limiting, the recommended rates of nitrogen to apply to malting barley may be excessive and result in unacceptable barley for malting. As mentioned earlier, high protein barley is difficult to malt uniformly and results in poor quality malt. Thus, it is not uncommon for growers to apply less than the recommend rate of nitrogen to increase their likelihood of producing acceptable malting barley. Knowledge on the effects of micronutrient deficiencies on barley is limited. Under some conditions, barley has been found to respond favorably to addition of chloride, copper, iron, and sulfur.

Fertilizers can be applied throughout the growing season; however, most nitrogen is applied prior to planting to ensure sufficient amounts are available for seedling establishment and tillering. Growers planting barley during spring often apply their nitrogen during fall to reduce their spring workload; however, fall application of fertilizers is not recommend for well-drained sandy soils because excessive leeching may occur over winter. The method of nitrogen fertilizer application is dependent on the source of nitrogen. Top dressing of fertilizers during the growing season is an option that is available if a nutrient deficiency is detected.

Variety Selection

Choice of variety for production is especially important for growers producing barley for malting and as a method to combat potential problems such as diseases, insects, and micronutrient toxicity. In all major malting barley growing regions of the world, different organizations evaluate and determine which barley cultivars meet their specifications. In the United States, this organization is the American Malting Barley Association (https://www.amainc.org). To aid barley breeders, the organizations responsible for evaluating potential new malting barley cultivars often provide specifications those cultivars must possess before they will be recommended for malting and brewing (http://ambainc.org/media/AMBA_PDFs/Pubs/Malting_Barley_Breeding_Guidelines_April_2017.pdf). Some of these groups also provide lists of cultivars that fit their specifications and are recommended for malting and brewing. In choosing malting barley cultivars for production, growers need to be aware of what cultivars are preferred by their local buyer. Even though there may be up to a dozen cultivars recommended for malting in a grower's area, local buyers may be purchasing only one or two specific cultivars. Growers should not only consider yield potential when choosing a malting barley cultivar to produce, but also its grain protein and kernel plumpness when grown in their area. For example, if going into the growing season the grower knows that stored soil moisture is limiting and residual nitrogen is high, they should choose a cultivar that has inherently lower grain protein even if it has a lower yield potential. Because of the premium paid for malting barley vs. feed barley, it is often better to sacrifice some yield to ensure the crop has acceptable grain protein and kernel plumpness.

Planting Date, Depth, and Rate

The desired planting depth of barley is between 0.75-1.25"; however, the planting depth of may need to be deeper so the seed is placed in moist soil. Because of the emergence mechanism of barley, it should not be planted deeper than 2.25". During germination, the stem internodes do not elongate, so the first node, coleoptile node, and growing point remain at the planting depth. About 2-3 weeks following emergence for spring-planted barley and after vernalization and temperatures warm up in the spring for winter barley, the second internode of the plant elongates until the growing point and other stem nodes are about 0.4" from the soil surface. The first and second nodes remain at the planting depth, and the tillers and crown roots develop from the remaining nodes.

The seeding rate for barley is dependent on many items, including the type of barley being grown (two-rowed vs. six-rowed) and whether the barley is being grown under dryland or irrigated conditions. The desired plant population can range between 28-30 plants per square foot (i.e. 1.25-1.30 million plants per acre). The lower plant population is recommended for barley grown under dry conditions while the higher population is recommended for barley grown under irrigation. Also, since two-rowed barley generally produces more tillers than six-rowed barley, lower plant populations for two-rowed barley can be used.

To determine the correct number of seeds to plant per acre, the grower must know the desired final plant population, the estimated seedling mortality, and the percent germination of the seed. The estimated seedling mortality can be based on prior experience and the percent germination of the seed is usually supplied with the purchased seed. If the seed is old or if the germination is not known, the grower needs to determine the percent germination he or herself. This can be done using a simple test where 100 seeds are placed between two pieces of damp paper towel and counting the percent germinated seeds after three days. It is important that the power towel is kept moist during the three-day period. The number of seeds to plant per hectare can be calculated using the following formula:

# of seeds to plant per acre = # of desired plants per acre x (1/ % seedling mortality) x (1/% germination).

For example, if the grower desires a population of 1.25 million plants per acre, the seedling mortality is 3 %, and the percent germination is 95 %, the grower would need to plant about 1.36 million seeds acre [i.e. (1.25 million plants acre x (1/0.97) x (1/0.95)].

The seeding rate to achieve the desired plant population is dependent on seed weight. To determine the correct seeding rate the grower can use the following formula:

Pounds of seed acre = # of desired seeds acre x (1000-kernel weight/1000) ÷ 1000.

For example, if the grower wants to plant 1.36 million seeds acre and the 1000-kernel weight is 42 g, the grower would need to plant 57 pounds of seed/acre (i.e. 1.36 million seeds x (42/1000) ÷ 1000).

EVALUATING MALTING BARLEY VARIETIES FOR NEW JERSEY PRODUCTION

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The resurgence of local brewing is evidenced by more than 4,000 American breweries. Craft beer is a reflection of the local food movement, similar to the consumer's desire to purchase local fruits and vegetables. The rise of the local movement has led to increased demand for beer made with locally grown ingredients. The marked increase in consumer demand for locally sourced specialty grains represents an opportunity for northeast producers. This is particularly attractive to existing grain farmers as they have the knowledge and understanding to produce grain crops. In addition, there are generally minimal capital and infrastructure changes which must be made to produce these crops. An emphasis on higher quality products over traditional commodity grade is one of the usual defining characteristics the specialty markets are seeking. Alterations to crop production and management are generally the predominate changes that must be made. The transition to producing such crops is generally easier for an existing grain farmer.

Although specialty grain production for the craft brewery market may present an opportunity for local producers, strict quality characteristics are required by the brewery industry in order to demand the pricing premiums needed to justify production. Currently there are few comprehensive guides or trainings that present the unique production requirements, economics, and marketing information needed by farmers to assess the sustainability of producing barley for the craft brewing industry. Furthermore, careful consideration must be made to not only select a variety that will produce a quality grain, but one that will also be suitable for the breweries needs.
In 2016, the Rutgers Cooperative Extension faculty and staff developed the Rutgers University Brewing Research and Extension Work (RUBREW) team. The team partnered with faculty from around the northeastern United States to evaluate several spring and winter malting barley varieties. This presentation will report the results of the variety trials conducted by the RUBREW team and will discuss the potential of malting barley production in New Jersey.

Post-Harvest

UNDERSTANDING AND IDENTIFYING *LISTERIA MONOCYTOGENES* RISK FACTORS IN PRODUCE PACKINGHOUSES

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Why is Listeria so important?

Listeriosis is a serious infection usually caused by eating food contaminated with the bacterium *Listeria monocytogenes*. An estimated 1,600 people get listeriosis each year, and about 260 die. The infection is most likely to sicken pregnant women and their newborns, adults aged 65 or older, and people with weakened immune systems. Mortality rates can be 20%–30% of those who contract listeriosis.

It is soil-borne and common in the outside environment; can multiply over a wide range of temperatures; can adapt to a variety of stresses and persist for long periods. Chances are high *Listeria* may enter a facility at some point, so it is vital for growers/packers to assess their operations for vulnerability to *Listeria* and manage the risk(s).

There may be *Listeria* present, but not *Listeria monocytogenes* which is the main concern so why test for *Listeria spp*.? It is faster to test to the species level also if source site has non-pathogenic *Listeria* it could be home to *Listeria monocytogenes.*

Has there been illnesses traced to produce?

The first big outbreak was Jensen Farms in Colorado during the 2011 production season. This was at a cantaloupe packing operation where whole melons became contaminated with *Listeria monocytogenes* resulting in 147 persons infected of which 143 were hospitalized, 33 deaths and one miscarriage. How the pathogen entered the packinghouse was not discovered, but it could have entered on a truck that took cull melons to a cattle operation. Also, the bacteria may have grown on the melons before cold storage. Listeria was found in corroded equipment; on the wet floor of the packinghouse; on conveyor belts and felt rollers.

Since the Jensen Farm outbreak there have been other outbreaks traced to sliced apples in 2013, late 2014 and early 2015 to caramel apples and a recall on whole apples in 2017.

Listeria Key Concepts

Transient *Listeria* – Enters the facility, but is killed/removed by sanitation program (it is reasonable to assume Listeria may enter on workers, equipment and tools from fields or pests).

Resident *Listeria* – Persists in the packinghouse, finds places to hide; not killed by sanitation steps; may move around the packinghouse over time and **in a worst-case scenario it may lead to recalls or outbreaks.**

Where could _Listeria_ hide? The answer is about anywhere equipment seams, drains, wheels of equipment, drip pans, filters, floors belts, cleaning tools, etc. so the whole packinghouse could have places for *Listeria* to survive and grow if conditions are right.

Controlling Listeria Before the Packinghouse

The first step is to minimize contamination in the field through worker training, good agricultural practices, etc. Keep the ground around the packinghouse free of weeds, old equipment, broken pallets, etc. Keep the grass mowed and make sure dumpsters are empty on a regular schedule.

Controlling in the Packinghouse

Where does the produce enter the packinghouse? Are there areas of standing water or excess moisture that may contact the produce or the packing containers? Are there pet issues; what about airflow that may blow over the product? How are the drains and floors designed to function and do they function properly? Is the equipment designed so it can be cleaned and sanitized easily? That does not mean you need all new equipment, but if it needs to be retrofitted do it right. These are just some of the questions to ask when evaluating the packing operation.

Limit the traffic flow of workers or equipment from the field into the packinghouse. The raw product should come in one entrance and exit another. This will reduce the chance for cross contamination of the raw and finished product.

After prevention, sanitation is the key to controlling *Listeria.* An environmental monitoring program can help identify the vulnerable areas in the packinghouse. Focus on niches/harborage sites e.g. where produce build up, end of the packing line, close to packaging, etc. How often and when to sample depends on the goal and outcomes from early sampling.

Make sure to establish corrective actions for positive samples in advance. A few examples are clean and sanitize then resample; determine root source and concentrate sampling in that area; retain employees; repair or replace equipment.

POSTHARVEST SANITATION, CASE STUDIES OF WHAT'S GONE WRONG?

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Postharvest sanitation is important for the removal of produce decay organisms and human pathogens from product contact surfaces. Product contact surfaces are any surface that touches the product from harvest to distribution. These surfaces will vary based on a farms production practices, but generally include: workers hands, harvest tools, harvest bins, bulk containers, conveyer belts, wash bins, packing tables and lines, workers hands, gloves worn by workers, and packing containers. Proper cleaning and sanitation of these surfaces will reduce the risk of cross contamination of decay organisms and potential human pathogens. The reduction of these organisms on surfaces will improve the overall quality of produce, increase shelf life and reduce the potential for human health risks. Food recalls because of human illness, or the identified potential for human illness, have become more commonplace due to advances in testing for these risk factors in produce. As consumers we have all purchased produce that did not meet our expectations because of rapid decay. In many cases improper product contact surface sanitation was a factor in reducing the quality of the produce. The quality of produce cannot be improved postharvest, but it should be maintained. Postharvest cleaning and sanitation of surfaces is critical to quality produce.

Common postharvest sanitation issues affecting produce visual and physical quality:

- Uncleaned surfaces allow for biofilms to form, fostering an environment for decay organisms to survive
- Physical damage from unclean surfaces, or improper product contact surfaces leads to decay organism infection through wounds
- Soil on contact surfaces not removed prior to sanitizing reduces efficacy of sanitizer. Allows for survival of decay organisms that enter through both wounds and healthy tissue
- Non-monitoring of sanitizer use resulting in excessive levels impacting the surface quality of the produce

Human pathogen outbreaks and recalls where sanitation could have reduced the scale of the problem:

- Strawberries contaminated with *E.coli* sold at roadside stands and farmers markets in 5 Oregon counties

    - Suspected source of contamination was fecal material from deer in the field
- Cantaloupe contaminated with Listeria distributed nationally to 26 states, 147 ill, 33 killed
    - No sanitizer used in the wash water, allowing listeria to survive and multiply on multiple surfaces in the packinghouse
- Fresh cut bagged lettuce processed at a Dole facility in Ohio was contaminated with Listeria, 19 confirmed ill, 1 death
    - Lettuce was processed at this facility and wash distributed under many brand names. A nationwide recall left grocery store produce shelves nearly bare of bagged lettuce
- Bagged spinach was sold nationally and caused 199 confirmed illnesses and 3 deaths in 26 states.
    - 4 production fields in California were identified as the potential source of contamination, including nearby cattle and one wild boar

SANITARY DESIGN AND PROPER LAYOUT FOR A PACKINGHOUSE

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1. Importance of sanitation
    a. Introduction
    b. Cleaning vs. sanitizing

2. Sources of contamination in the packinghouse
    a. External sources: harvest and transport
    b. Internal sources: receiving through shipping; water usage
    c. Worker training and supervision

3. Considerations for sanitary design
    a. Structure: open vs. closed
    b. Contact surfaces: floors, walls, equipment
    c. Ease of cleaning and drainage
    d. Unloading methods
    e. Cooling methods; cold storage areas
    f. Field containers

4. Considerations for proper layout
    a. Product flow: receiving, packing, cooling, storage, shipping

Small Fruit/Strawberry

ORGANIC STRAWBERRY PRODUCTION AND MARKETING

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- **Farm History & Background**
    - 10th season in MD.
    - Non – certified organic Pick your own (PYO) strawberries
    - 700 member CSA
    - Started strawberries by default
        - I thought it might bring people down our driveway
        - It went better then expected our first season & was greatly enhanced when we added large road signage and social media
        - We had a 1 hour checkout line that went over 250' long, we couldn't keep up with sales.
        - People travel long distances for organic berries.
- **Plasticulture production – fall plantings & spring harvest.**
    - Grown like an annual, not carried over year to year
    - Transplanting plugs in fall for following year May-June harvest.
    - Drip irrigation and fertigation schedule based on petiole analysis
- **Understanding Strawberry plant seasonality**
    - Strawberry Plant becomes what it is going to be in the fall
        - As the plants come out of dormancy in spring - all of the potential is already there. As well as weed pressure
    - Winter - dormancy, protect it from stress for maximum resurgence in spring.
    - Spring - plants wake up and push growth fast. Growth is based on fall planting foundation and winter protection.
    - Late spring & early summer - quick & super abundant harvest
        - Hi quality & quantity harvests last about 3 weeks. Can push for additional 1-2 weeks of less than par harvest pending weather/pest/disease and crop maintenance practices. Don't count on it for budgeting.
    - In summer the plants poop out and get diseases. (Rip them out, renovate & start over. They are perennial but not worth carrying over, in my opinion, pending your scale and marketing potential)
- **Plant growth**
    - Mother plant and Side crowns
    - **Buds**
        - Stages of Bud emergence

        - Pre-emerging, popcorn stage, full bloom
    - Buds are very frost & disease (botrytis) sensitive
    - Frost protection
        - Row Covers in winter. Row covers on & off all through spring – monitor freezes and bud stage accordingly
- **Varieties** – June Bearing Plasticulture vs. Day Neutrals vs. Matted Row
    - We grow Chandler and Flavorfest as June bearing
- **Sprays**
    - Purpose Plus (Cheaper version of Oxidase) 3x in a row just before row covering in fall early winter. Preventative measure.
    - M-pede miticide/ fungicide / Copper /Regalia
    - I almost never spray anything coming out of spring in the year of the harvest. My customers find this very important, and I want my staff to be able to say no sprays confidently. (This is an ambiguous area; we don't promote that or brag about it. Getting customers to understand farm practices is an uphill battle I like to avoid. But when asked I want the answer simple easy and to satisfy. If the crop needs it I will do it. Organic vs. Conventional systems and spray efficacy and necessity can be hard to gauge.
- **Pests**
    - 2 Spotted spider mite
        - Hand remove large decaying older leaves touching plastic. 1-2 x in spring pending mite pressure
        - Release predatory mites (presimilus) in spring just prior to harvest when temps are correct
    - Sap Beetle
        - Clean up old fruit or missed ripe fruit after you pickers have done most of the picking
        - Beetle is inevitable and drastically reduce sales if red fruit is left in the field
    - Aphids
        - Keep an eye can become an issue under row covers if too warm
- **Disease Pressure**
    - Anthracnose fruit and crown rot. Can be identified in runners in previous fall. Legion or dead spot in runners.
        - Fruit rot will present in chandler not Flavorfest when wet and hot. Not if but when.
    - Botrytis fruit and crown rot

        - Always present sanitation practices will drastically reduce potential. Remove total plants that are dropping with Botrytis crown rot.
    - Angular leaf spot
    - Downey Mildew
- **Row Covers & Frost Protection**
    - Double row covers if needed in spring with emerged buds and very low temps
    - Wind and rock bags or rock socks almost touching for secure hold down of covers
    - Can push flowering and mite pressure
    - Problematic with lack of pollination in spring
    - Labor costs with covers on and off
    - We are row covers on and off at least a dozen times in spring
    - Animal damage to row covers / reusing covers for next season
    - Don’t take chances not covering
- **Sprinkler Frost Protection**
    - A game for the pros – be careful here. You must understand how it works and can do more damage than good if not done correctly.
    - Problematic in heavy soils with poor drainage you may need to flood your fields in order to get correct frost protection
    - Involves sophisticated weather monitoring systems, solid irrigation / sprinkler set up. Prepare to be up all night
    - More than just temperature related. You need understanding and proper monitoring of dew points, wet bulb, evaporative cooling.
- **Organic Practices for disease suppression sanitation and weed prevention**
    - Full field, plant for plant, hole for hole weeding, decaying leaf removal, and runner removal in fall and spring. All debris needs to be removed from the field. Sanitize snips if clipping runners to not spread disease
    - Early spring may want to remove row covers just for this step then re-apply.
    - Rotate out of strawberries for 4 years. 3 years from salacious crops.
- **Fertility**
    - Sample strawberry beds before bedding or for selecting best location
    - Leaf petiole analysis in spring
    - On average (but pending petiole analysis) 5lbs N per week all through flowering. Keep plants strong and healthy through

harvest could extend harvest or get a last flush with sales potential.
        - Too much N = mushy fruit, makes mites explode
    - Chandler likes a lot of nitrogen, Flavorfest less
    - Sodium Nitrate 16-0-0. 5lbs actual/week
    - Sulfate of Potash 0-0-52 - as determined by lab analysis
    - Epsom salts for Mg deficiencies - as determined by lab analysis
    - Actinovate in fall for disease suppression
- **Harvest**
    - Pick your own does all the picking
        - First fruit prior to “glut” of fruit we may need to pick
        - Still need to clean up fields after you pickers
        - Heavy rains that damage fruit need to be hand removed by on farm labor. Anthracnose fruit rot needs to be removed
- **Sales**
    - Plasticulture June bearers are expensive, short lived but super high yielding.
    - Aim for retail and bulk audience cash sales
    - Strawberries don’t hold well or long. Picking is non-stop and you better move them quickly.
    - If your customers try them they will buy them
    - Aim for $50k/acre in sales with ~$20k/acre in costs
- **Pick your own logistics**
    - Parking, Point of sale, picked out, managing fields and moving customers, baskets, scales, pricing.
        - Organic strawberries are worth $8/quart & $4/pint.
        - PYO at $5-$6/lb.
    - Try to clean out or finish a field with picking for management efficiencies.
- **Refrigeration**
    - Chandlers don’t come out of refrigeration well – go mushy and sweat
    - Flavorfest holds up better
    - Fresh picking to sales immediately is best result.
    - If you have to refrigerate learn your temps and be careful.
- **Equipment and bedding process**
    - Plow in cover crop – can you fit a summer legume in prior to bedding. Soy beans?
        - Try to always have a cover crop prior to strawberry.
        - Have gone straight out of cash crop to renovate field and prep for berries. Not recommended and not on every field.
        - Select better-drained fields for berries.

        - Compost or composted manure a top chopped cover crop & incorporate
        - Chisel Plow – Rototill – Bed shape with bagged Nitrogen in beds. Plastic layer with drip down middle. Crowned beds is ideal as standing water causes disease issues especially anthracnose during harvest or fruit sitting in water.
            - Pre bed w/out plastic 1-2x before plastic. Make beds solid and firm. You don't want settling over winter. Be able to walk on beds with out sinking
        - We plant dbl rows at 12". 18" better air flow if you can afford the space. You want as much space and air flow but be careful with plants to far to edge of plastic as you will most likely need to mow &/or weed whip weeds between beds and this damages fruit
    - **Cover cropping between rows & weed control**
        - I don't like annual rye, to hard to control
        - Have used forage radish and oats but not very happy with results.
        - For 2018 I'm trying a fescue sod to not have winter kill and help absorb moisture create a better path for you pickers and easier mowing regiment
            - 2018 we hand hoed the plastic edges to remove chickweed
        - Chickweed and Henbit tends to dominate plastic edges and can swallow the crop. Don't worry but you must remove it
        - We cover crop with a drop seeder and rolling basket behind a BCS walking tractor. This does not cover the shoulder.
            - Ideally 2 cultivations after transplanting and then seeding. Timing is critical to get seed up and to flush 1st two rounds of weed seeds. Fall rains can wash your seed out. I tend to seed heavy. Need to balance field crew fall plant clean up which can destroy your tender emerging between row cover crop.
    - **Plant / Plug sources**
        - Aaron's creek, Kube Pak, New Jersey Asparagus/Walker bros.
            - Not for certified organic
            - Certified you may need to raise your own plugs from bare roots. Good luck watering every 10 minutes in a greenhouse in July. Not for me.
    - **Strawberry industry resources.**
        - North Carolina strawberry growers convention.
            - A must at least once if planning on more than 1 acre. Organic or not these are the pros on the east coast there is much to be learned.

- Wye research in MD.
- Go see NC or large plasticulture operations – PYO logistics – Scale – Industry knowledge
- Barclay Polling NCU.
- Skybit – precision GPS location weather data, subscription based

EXTENDING STRAWBERRY SEASON USING DAY NEUTRAL VARIETIES AND LOW TUNNELS

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For the last two years at the University of New Hampshire we have been working with plastic-covered low tunnels and day neutral strawberry varieties with the objective of extending the region strawberry production season and improving berry quality. We are a collaborator on the USDA-funded TunnelBerries project, where researchers at multiple universities are investigating the role protective structures, such as low and high tunnels, can play in supporting the berry industry in the Northeast and Upper Midwest. Grower resources and more about the project can be found at www.TunnelBerries.org.

Day Neutral Strawberries

Years ago, some growers were quick adopters of early day neutral varieties but were disappointed by the low yields and small fruit size of these plants. However, a new generation of varieties has been available for years now and several appear suitable for Eastern production. Many of these varieties were bred for west coast production, but regionally adapted cultivars are being developed and released periodically by breeding programs in the Northeast and Mid-Atlantic.

Unlike June-bearing strawberries, day neutrals continue to produce flowers and fruit throughout the summer and fall months. Many day neutral varieties will begin producing fruit within 10-weeks of planting and will continue as long as temperatures permit, until as late as December under low tunnels in mid-Atlantic locations (USDA-ARS in Beltsville, Maryland). In New Hampshire, dormant bare-rooted plants are planted in early spring into raised beds covered with plastic mulch and drip irrigation. Runners are removed periodically (at least monthly) to ensure energy goes to fruit production, and plants are fertilized through the drip irrigation system throughout the season. Plants can be managed as an annual crop, or over-wintered for spring production in Year 2. If overwintered, spring production begins before June-bearers. Plants will also produce a second crop in the summer/fall of Year 2 and may or may not be over-wintered a second time.

Why Low Tunnels?

Plastic covered low tunnels are an affordable and portable alternative to high tunnels and are found in strawberry production regions throughout the world. They have not been widely adopted in the U.S., possibly since the majority of strawberry production occurs regions with optimum growing conditions. However, these protective structures may be particularly useful in locations where precipitation is common and damages fruit. Low tunnels assist in both prolonging production into the fall months and in creating a warmer environment for growth in the early spring.

UNIVERSITY OF NEW HAMPSHIRE EXPERIMENTS

UNH research has focused on estimating production for the day neutral variety 'Albion' both under low tunnels and in open field production. We have also been evaluating the effect of various mulch and low tunnel plastics on production.

Planting & Management

During two years, 2016 and 2017, we evaluated the effect of mulch color (black, white-on-black, and no mulch) and low tunnels on yield. Our experiments were managed as an annual system, with plants installed in the spring and discarded in the fall of both years. Plants occurred on 9 May 2016 and 28 April 2017 in double rows 12" apart, with an in-row plant spacing of 16". Beds were raised and equipped with a single line of drip irrigation. Once flower trusses began emerging, they were removed for a solid three-week period to ensure plant establishment. Runners were removed bi-weekly throughout the experiments.

Pests

Aphid, leafhopper, various caterpillars, and tarnished plant bug have required management in both years. Additionally, Oriental Beetle grubs (white grubs) have been the most significant pest we have encountered and after serious damage from soil grubs in 2016, they were managed with one application of Imidacloprid (10 oz/acre) in early-August of 2017 when adult beetles were found at the base of plants, presumably laying eggs. Ideally, this pest would be managed early spring or late season so that management does not interfere with fruit harvests. Spotted Winged Drosophila (SWD) was not found in our experiments in 2016, but was detected in September of 2017.

Fertility

We applied 60 lbs of both Nitrogen (calcified ammonium nitrate) and Potassium (sulfate of potash-magnesia) pre-plant (and following a soil test). Given the long production period of day neutrals, they require additional fertility throughout the season, ideally weekly through drip irrigation. We applied between 2-5 lbs Nitrogen per acre per week using a 21-5-20 all-purpose soluble fertilizer and a dosatron liquid dispenser.

NH Results

- 'Albion' began fruiting within 8-10 weeks of planting in NH (by early July in both years), and continued for ~20 consecutive weeks until mid-November, in both years.

- Total annual yield averaged 10-14,000 lbs/acre (Figure 1), greater than the annual yield reported for June-bearers in the region.

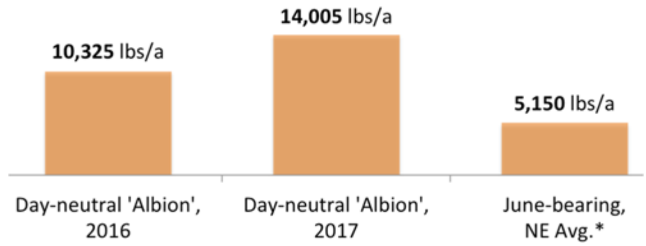


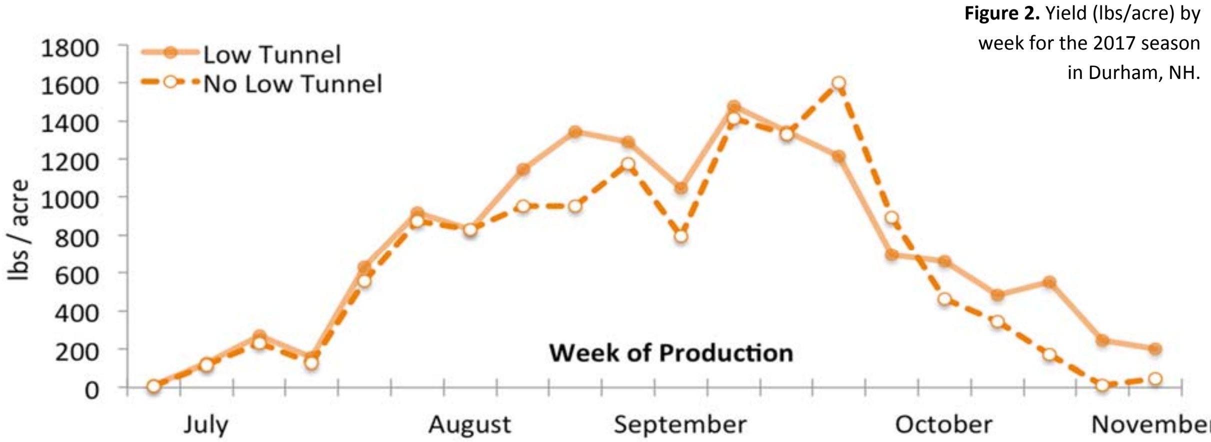
Figure 1. Annual yield is an average of all treatments, for 1st year production only, and based on 13,068 plants/acre. *Reported by the USDA-NASS, 2016.

- Plants on black plastic and white-on-black plastic mulches produced significantly higher yields than un-mulched beds. Yield from black and white-on-black mulches were not statistically different.

- Total (season long) marketable yield (lbs/plant) did not differ between plants covered by low tunnels and open field production (no low tunnel). However, total unmarketable yield was reduced under low tunnels, but about 50%.

- While the season lasted from July through November, 'Albion' produced the greatest yields during August and September (Figure 2). Low tunnels promoted/protected fruit production late summer and during the month of October, when yield under low tunnels was greater five consecutive weeks.

Figure 2. Yield (lbs/acre) by week for the 2017 season in Durham, NH.



The DN variety 'Albion' on 8 Sept. 2017 (left) and 3 Nov. 2017 (right). In the picture on the right, fruit in the quart container on the left was from plants not covered by a low tunnel, and on the right, from plants under a low tunnel.

Takeaways

Experiments conducted elsewhere (Maryland, Canada, Minnesota) find low tunnels have the ability to increase marketable yield. This was not an outcome in our two-year experiment, possibly due to two very dry years during the study (2016 and 2017). We observed low tunnels increased marketable yield following precipitation and at several points during the season. Unmarketable yield was reduced significantly under low tunnels, resulting in 50% less cull fruit, and therefore, a higher *percentage* of marketable fruit under low tunnels. Additionally, we found the use of plastic mulch increased marketable yield when compared to unmulched beds. By prolonging the season by ~20 additional weeks and producing high annual yields, the day neutral variety 'Albion' complements the traditional June-bearing season well in our location.

Tips

For the earliest fruit production and longest season, it is very important to plant early spring (late April in NH). It may be possible to use 12-14" plant spacing with the variety 'Albion' because the plants tend to be somewhat compact. Both DN cultivars and low tunnels require management throughout the growing season (runner removal, fertility, raising/lowering sides for rain protection, etc.). Proper installation of low tunnels is key to easier management throughout the remainder of the year. UNH will be releasing a low tunnel strawberry production guide in the coming months, which may be found at: **https://extension.unh.edu/Grower-Resources/Research-Reports**

Low tunnel cost & benefits

A complete low tunnel system (steel hopes, plastic, bungee elastics, grounding pipes, etc.) requires an initial investment of approximately $20,000 per acre. NY State growers report gross sales from 'Albion' of $50,000 per acre per year. Access to direct market sales at a minimum of $4/lb could certainly increase gross revenue up to $80,000/acre (assuming 20,000 lbs harvested). Thus, the investment in a low tunnel system should pay for the materials in the first year, with second year costs including plants, fertilizer and labor. Plastic will need to be replaced periodically, depending on product used. The direct financial benefits of investing in a low tunnel system will certainly be affected by the environmental conditions of a given year and location, as well as the value a given producer places on protecting the crop. Low tunnels may be considered a form of crop insurance, as they are likely to pay off during precipitation, poor weather, and late season.

Valuable Resources

Season Long Strawberry Production with Everbearers
http://www.sare.org/Learning-Center/SARE-Project-Products/Northeast-SARE-Project-Products/Season-Long-Strawberry-Production-with-Everbearers-for-Northeastern-Producers

Extending Local Strawberry Production with Day-neutral Cultivars and Low Tunnel Technology
http://www.hort.cornell.edu/expo/proceedings/2016/Berries.Extending%20local%20strawberry%20production%20using%20day%20low%20tunnel%20technology.Pritts.pdf

TunnelBerries Project: www.tunnelberries.org

UNH Strawberry Research Blog: www.kaitlynorde.com

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FOUR YEARS OF MANAGING SPOTTED WING DROSOPHILA USING EXCLUSION NETTING

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The arrival of Spotted Wing Drosophila (SWD) has been a game changer for every berry grower in the United States. SWD arrived in our blueberries in Stephentown NY in 2012, and since we had always been a no-spray farm, this pest caused a 40% crop loss in our blueberries that year. Determined not to have such a loss in the future, we sprayed our blueberries for this pest in 2013. We have a half acre of blueberries, with mature, very healthy bushes, which meant that we could not use a tractor mounted sprayer to spray the planting. We also harvest 7 days a week during harvest season. The combination of pre-harvest intervals, weather events, battery-powered sprayer limitations, and physical limitations of carrying a 40-50 pound sprayer on my 120 pound body made me decide that another way had to be found to manage SWD.

In 2014, I received a Northeast SARE Farmer Grant to explore using exclusion netting for SWD management by adapting my existing bird netting support structure. In my first year, we compared 60 gram ExcludeNet netting to 80 gram ExcludeNet netting manufactured by TekKnit Industries in Montreal, Quebec. The netting was deployed on July 10-11, with the first of the Duke blueberries ripening. While the 60 gram netting delayed infestation by SWD, high levels of infestation occurred by the end of the season. The 80 gram netting had a total of **0.67 percent** infestation over the course of a 10 week harvest season. We had the highest yields **ever** that year. A key component of my netting system is having one defined entryway. We constructed a double-door entryway to minimize the ability of SWD from being introduced accidentally into the planting. I believe that having one defined entry, with an easy in/easy out system (a zippered doorway) is key to making an exclusion netting system work.

Seeing the potential of the system, and using the material for one year gave us ideas on how to change our attachment system for the netting in 2015. In 2015, we got the netting up one week earlier – on July 5-6. It was a smaller crop that year and a shorter harvest season. We had **0.37 percent** infestation over the course of a 6 week harvest season.

Two years in a row taught us that this material really works so our focus in 2016 was to get it up even earlier and to start to think about ways to make it easier to put up and ways to address the issue of “what do you do if you get an infestation inside the netting”. We deployed the netting on June 29-30 in 2016. Over the course of a 9 week harvest season, we had **0.00 percent** infestation. Not one single berry out of over 2000 berries sampled had SWD larvae! We also had an observational trial, consisting of 2 replications, of an “attract and kill system”. This system is made of red spheres, with an insecticidal cap comprised of spinosad insecticide and sugar in a slowly dissolvable material. Once the cap is “activated” with water (with a mist bottle in my case, or with rain in a standard summer), SWD are attracted to the red color, land on the red sphere, feed on the sugar/spinosad mixture, and hopefully, die. We also added an attractant lure to the sphere to further attract SWD. The spheres were hung in blueberry plants in small netted plots, but which we purposely set up to allow SWD to invade (entering to harvest by picking up the side of the netting, not attaching tightly at the bottom, not repairing small holes in the netting). Preliminary data from the spheres was very promising so we expanded the trial in 2017 to 4 replications.

In 2017, we deployed the netting later than we wanted (July 4th), thanks to being busy with the late strawberry harvest. We had ripe Duke blueberries when the netting went up. In 2017, the first SWD was caught in NYS in May, and the first SWD was caught at our farm in mid-June. On June 27th, there were three SWD caught in the ripening Dukes in the area that was eventually covered with netting. On July 5th, four SWD were caught in one trap inside the netting and on July 10th, 20 SWD (19 females) were caught in the ripe Dukes inside the netting. At that point we went on a sanitation blitz, making sure that no dropped fruit were left on the ground and our crew started harvesting bushes with sheets of plastic underneath so that all dropped berries were removed from the planting every day. We set up a systematic harvest schedule so that every bush was harvested twice a week and I deployed both red attractant spheres with insecticidal bait and six SWD traps to do some “mass trapping”.

Trap counts went down and we did not detect any larvae in fruit for several weeks. In late July, during an evening evaluation inside the planting, I observed one SWD on one berry. Two days later, two small larvae were detected in our weekly sample of 225 fruit. The larvae were from the area with the ripe Dukes and the trap that picked up the first adults. After consulting with Greg Loeb and Laura McDermott, I made the decision to make an application of spinosad insecticide and continue to monitor the fruit infestation results to decide if another application would be needed. So that we could continue to harvest, I sprayed one half of the front of the planting that had ripe and ripening fruit, focusing on the lower part of the bushes. Three days later, I sprayed the other half of the front of the planting. Infestation results went down to zero, and trap counts continued to be very low. Because of that, I did not make any more applications in 2017. I believe the combination of sanitation, mass trapping, and attract and kill spheres enabled me to manage the SWD population that had already established itself prior to deploying the netting. Only four larvae were detected in over 1200 berries sampled from netting deployment until August 21st, when there was an uptick in the number of larvae found. Most of the larvae were found in bushes that were no longer being harvested, later varieties that still had lots of fruit were still clean. We harvested fruit from July 7th to September 15^{th,} a ten week harvest season. In 2017, my crop was the largest ever, exceeding my 2014 record by 19%.

I learned many things regarding the netting system. This system has worked far better than my greatest dreams for using the netting. Besides the obvious benefits of being able to again grow blueberries without having to spray for SWD, the netting provided other protection. Over the four years that I have used the netting, my crop has been protected from three hail storms; five severe thunderstorms with 30-60 mile per hour wind gusts; numerous hard rains, and of course, birds. The netting breaks the wind and diffuses heavy rains so that I no longer see ripe berries coating the ground after a heavy rain or thunderstorm. I don't believe it is a coincidence that my top three production years have been during the four years that I have been using the netting.

My talk will focus on how we set up our system, aspects of the system that we have changed over time, the cost and payback time for the netting, and the results of the research that we have done over the last four years.

Future research needs to focus on structure design – what is the easiest, most economical way for growers to construct a support system for their planting. Should it be posts and wires? Should it be a hoop system like I adapted from old high tunnel parts? Should it be a modified shade structure? Should it be something that no one has yet envisioned? Every farm will be different based on their own knowledge and resources available.

In 2017, for the first time, I also used exclusion netting on my high tunnel raspberries, again using a double door entry system. It worked extremely well, despite my raspberries having 22 larvae **per berry** prior to setting up the netting. Over the six week period that we collected fruit and sent it to Geneva for testing, we had 1.2% infestation. More information about the raspberry work is available by contacting me.

Netting can be obtained from Berry Protection Solutions. Contact information is: berryprotection@fairpoint.net or 413-329-5031.

Farm Equipment/ Pesticide Safety

PROTECTING YOURSELF USING CHAINSAWS

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The National Safety Council has consistently ranked agriculture as one of the top three most hazardous occupations in the United States. Because of its broad scope, the farm environment is not limited to any one particular kind of hazard. The farm possesses a multitude of dangers including falls, burns, poisonings, machinery, livestock, and environmental hazards. Factors that contribute to an unsafe work environment include a limited work force with seasonal time pressures, dependency on weather conditions and variation in weather, and a stressed economy including urban-rural competition for productive farm acres. Although farmers account for 2% of the workforce population, they experience a high rate of the work-related injuries and deaths.

Chainsaws are consistently ranked in the list of top five most dangerous tools to use, and as such should be handled much more cautiously than simply picking up a hammer or wrench. And because farmers are inherently independent and necessarily multi-taskers or "Jack of all trades (master of none?)," impatience, over-confidence, fatigue, and even disregard for commonly practiced safety protocols have led to numerous injuries and even fatalities when using power equipment such as chainsaws.

Following are a number of other relevant statistics:

- According to the U.S. Consumer Product Safety Commission, there were more than 28,500 chainsaw injuries in 1999.
    - Of those, more than 36% were injuries to the legs and knees.
    - Approximately 40% of all chainsaw accidents occur to the legs and well over 35% occur to the left hand and wrist.
    - The average chainsaw injury requires **110 stitches**.

- More recent data (University of Arkansas, 2009-2013) revealed a total of 115,895 emergency room visits for injuries related to the use of a chain saw in the US:
    - Most injury visits occurred among males (95%)
    - Persons aged 30–59 years were injured
    - Predominantly during the months of September through November.
    - The main body sites injured were the hand/fingers and knee.
    - The majority of injuries were lacerations (80%)

- **Chaps or chainsaw pants as well as keeping *both* hands on the saw would reduce chainsaw injuries by 75% or more.**

There are two primary factors at work here. The first is that all of us come to our thinking and use of chainsaws with different educational backgrounds, different training and experiences. When there is confusion, and when up-to-date knowledge, skill or experience is lacking, there will also be a lack of critical thinking, decision-making and operational behavior, and the potential for injury will increase.

The second of the two primary factors is that time and again, chainsaw users are put in a position to figure out a way of getting the job done quickly, regardless of proper safety and skills training: potential lack of accurate education + time constraints = engaging in unsafe work practices and bad habits.

Personal Protective Equipment (PPE)
While usually mentioned strictly regarding the proper use and application of pesticides, working with chainsaws also presents a unique set of hazards which PPE can help prevent or lessen the severity of injuries from those hazards. As with all PPE, it must be available to the user and inspected regularly to ensure it is in acceptable condition. When hazards make it necessary, OSHA mandates that the following PPE must be worn:

- Head protection - helmet
- Hearing protection – ear muffs or plugs, **NOTHING** can restore lost hearing
  - A chain saw has a sound intensity of about 109 dB. Without proper hearing protection, running a chain saw for only 2 minutes can cause hearing loss! If you need to raise your voice to be heard an arm's length away, the noise is probably loud enough to damage your hearing.
- Eye/face protection – safety glasses or face shield
- Leg protection – chaps or chainsaw pants
- Foot protection – steel tip / shank boots
- Hand protection – gloves
- Alertness – working alone or in groups, know your surroundings and review them regularly

Hazards to youth
As farmers age, there is a tendency to have younger family members or hired workers handle some of these tasks, possibly leading to a generational shift in these injuries and reaffirming the need for more and better education and training. According to the CDC, of the leading sources of fatalities among all farm youth, 25% involved machinery, 17% involved motor vehicles (including ATVs), and 16% were drownings. Furthermore, while overall numbers of farm injuries are declining, injuries to farm household youth have held steady. The CDC recommends, among many other safety protocols, to assign age-appropriate work, provide training and supervision, and provide a safe environment and equipment. But do farmers actually provide that for themselves?

Modern chain saws have many safety features designed to reduce laceration injuries. Chain brakes are manually engaged brakes that prevent the chain from moving in between cuts or other operations. Generally located on the top of the tool, a handle can be pushed forward to engage the brake or pulled back to release the brake. Some models also have a safety throttle that acts as a “dead man” switch in the event the chain saw slips or is knocked out of the operator’s hand, thereby immediately disengaging the throttle and activating the chain brake automatically. Similar to a chain brake, many chain saws are equipped with a centrifugal clutch which disengages the chain when the chain saw is resting at idling speed. Lastly, a chain catcher is a metal or plastic guard designed to prevent a broken chain from striking the operator.

In addition to product design, several operator behaviors have been implicated in these injuries. Operators should cut at waist level or below due to the difficulty in managing the chain saw when trying to cut overhead. A sharp chain will result in much smoother cuts and require less force by the operator to complete the cut, thereby reducing the risk of the operator using excessive force or movement of the chain saw which may lead to kickback and falls.

Operating a chain saw is inherently hazardous. Potential injuries can be minimized by using proper personal protective equipment and safe operating procedures.
www.osha.gov/Publications/3269-10N-05-english-06-27-2007.html
Before Starting a Chain Saw

- Check controls, chain tension, and all bolts and handles to ensure that they are functioning properly and that they are adjusted according to the manufacturer's instructions.
- Make sure that the chain is always sharp and the lubrication reservoir is full.
- Start the saw on the ground or on another firm support.
- Start the saw at least 10 feet from the fueling area, with the chain's brake engaged.

Fueling a Chain Saw

- Use approved containers for transporting fuel to the saw.
- Dispense fuel at least 10 feet away from any sources of ignition when performing construction activities. **No smoking during fueling.**
- Use a funnel or a flexible hose when pouring fuel into the saw.
- Never attempt to fuel a running or HOT saw.

Chain Saw Safety

- Clear away dirt, debris, small tree limbs and rocks from the saw's chain path. Look for nails, spikes or other metal in the tree before cutting.
- Shut off the saw or engage its chain brake when carrying the saw.
- Keep your hands on the handles, and maintain secure footing while operating.
- Proper personal protective equipment must be worn when operating the saw, which includes hand, foot, leg, eye, face, hearing and head protection.

- Do not wear loose-fitting clothing.
- Be careful that the trunk or tree limbs will not bind against the saw.
- Watch for branches under tension, they may spring out when cut.
- Gasoline-powered chain saws must be equipped with a protective device that minimizes chain saw kickback.
- Be cautious of saw kick-back. To avoid kick-back, do not saw with the tip. If equipped, keep tip guard in place.

CANCER RISK AND AGRICULTURE

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Cancer rates and agricultural health are complicated topics, put them together and it even gets more complicated. One in two men and one in three women will develop cancer of some type in their lifetime, no matter what they do, what they eat, or where they live. My focus today will be cancer risks and agriculture.

Farmers as a group, are healthier than the average person. Some would argue that you need to be healthy to remain in agriculture and remain a famer, I would agree. We call this phenomenon the healthy worker effect. You do not see a lot of sick people in farming because of the large amount of physical effort and hard work that it takes to be a farmer, so if you are not healthy you drop out of the work force. We see the same trends in construction workers, builders, any occupation that requires a lot of hard physical labor.

So, the question becomes, what kinds of cancers are farmers more likely, and less likely to get? There are some obvious ones, farmers as a group have higher rates of melanoma and lip cancer, the explanation is that they are out in the sun more than others and have much higher exposure to the UV rays from sunlight. An early study that was published and got us all to think about farmers and caner was work done by Dr. Aaron Blair at the NCI. Dr. Blair looked at pesticide exposure and 2,4-D and the higher rates on Hodgkin's lymphoma, multiple myeloma, leukemia and melanoma in farmers. Many people dismissed this, and they were wrong, they said Dr. Blair did not understand farming, again they were wrong. Dr. Blair grew up on a soybean farm in North Carolina, he is a farm boy, he knows what he is talking about.

There are direct benefits of pesticide use and we know we enjoy the plentiful and inexpensive food supply we have because of pesticides. Pesticides allow us to grow more, grow for less cost, and produce higher quality crops. But there are downsides to exposure to pesticides. The biggest issue for all of us in agriculture is to reduce our exposure. Some of us remember DDT, the chlorinated compound that saved millions of lives controlling mosquitoes and preventing malaria, it also was critical in controlling body lice which transmit Typhus and of course it was a very large part of the new era of agriculture post World War II. But we also know it is be an endocrine disruptor, Rachel Carson's book Silent Spring was some of the first evidence that the DDT effects the calcium distribution in bird's eggs making them unstable and causing them to break, hence the silent spring, no young birds singing in the spring.

We know now that girls who were exposed to DDT before puberty have a five times greater risk of developing breast cancer as adults. So, with every new solution comes a significant new set of problems.

My talk today will focus on the cancers we know are related to farming, I will discuss some of the work of the Agricultural Health Study (AHS), some of my own work, and we will look at ways to reduce your cancer risk. I refer you to the National Cancer Institute Agricultural Health Study as an extensive source of information https://aghealth.nih.gov/

Examples in my presentation will include data from the AHS. About 60% of the spouses of pesticide applicators in the AHS reported using pesticides themselves at some point. Lerro, et al used information reported by wives of pesticide applicators to take a first detailed look at the use of organophosphate (OP) insecticides and cancer risk among women. Women who reported using OP insecticides were more likely to develop breast cancer than women who never used these insecticides. In addition, some specific OPs were associated with other cancers: Malathion, the most commonly used OP insecticide, was associated with an increased risk of thyroid cancer. Diazinon, another common OP insecticide, was associated with an increased risk of ovarian cancer.

The AHS found a link between insecticides and aggressive prostate cancer. Farmers are more likely than other men to develop prostate cancer. In 2003, AHS researchers reported an association between some pesticides and prostate cancer among those with a family history of prostate cancer. In 2013 AHS did an analysis of 2,000 men in the study who have developed prostate cancer. The strongest evidence in the study was for a link between a few specific insecticides and a subtype of prostate cancer that is fast-growing or aggressive. This finding was based on information from AHS participants who answered questions about their lifetime use of 50 different pesticides when they enrolled in the study between 1993 and 1997 and then again 5 years later.

Researchers found that frequent users of the insecticides malathion and terbufos were more likely to develop aggressive prostate cancer, compared with participants who did not use either insecticide. Fonofos and aldrin, insecticides that are no longer registered for use were also associated with an increased risk of aggressive prostate cancer.

IPM Issues

ALLIUM LEAFMINER IN PENNSYLVANIA

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The Allium leafminer (*Phytomyza gymnostoma*) was first identified in the US in Lancaster County, PA in December 2015. Since then this insect has been identified throughout SE Pennsylvania, New Jersey, Maryland and New York. The adult is a small fly which feeds on plants in the Allium family. We have found this insect in onion, garlic, leek, chives and garlic chives and a number of ornamental alliums. In addition, it will feed and reproduce on wild garlic.

Allium leafminer has two generations per year and overwinters as a pupae at or near the soil surface. From our 2016 and 2017 surveys, spring emergence starts in April and continues well into May. The adults are feeding and laying eggs into whatever allium plants are available during that time. We are noting that there seems to be some feeding preferences in these insects – younger plants over older plants and some species of allium over others. Eggs are laid inside the leaves of a plant and the larvae tunnel downward and pupate in late May or early June.

The pupae have a dormant period over the summer and emerge as adults in the fall. Our surveys show this second generation starting in mid- to late- September (about September 20 or soon thereafter). Fall adult flight continued into early November in 2016, but it 2017 it seemed to end earlier, by about the 2nd or 3rd week of October. These fall adults also lay eggs into allium leaf tissue, which hatch into larvae and develop into the pupae that will overwinter. Farms with a continuous supply of allium hosts such as chives, onions, leeks, garlic, as well as weedy alliums provide a host for both the spring and fall generation and these farms may be most at risk.

We have been evaluating various colors and patterns of sticky traps in the hope of being able to use trap captures as a monitoring tool to determine when this flight activity occurs. Adults, however, appear to have a short lifespan and efforts to monitor adult flight activity with various colors or patterns on sticky traps have resulted in very low capture rates. We have documented higher capture rates on traps that are yellow, black, or yellow with a black grid as compared to several other colors from on-farm trials. However – it does not appear that the use of sticky traps will be an effective method to monitor for the presence of adult allium leafminers based on comparison of trap counts to visual scouting of plants for injury and/or the presence of adult flies.

In fall 2017, two research trials were conducted at the Southeast Research and Extension Center in Landisville, PA. To look at a trap cropping management approach, one trial looked at whether the variety or plant age of bunching onions present influenced infestation rate. We compared 2 varieties, Nebuchan and Evergreen, planted from seed, and 5 plant ages (105 to 170 days from seeding), in a replicated split plot design. The number of leafminers per plant (summed for both larvae and pupae), which varied from 0 to greater than 15, did not follow a simple linear pattern. This was due to low infestation rates in the very youngest plants, which did not establish well and had high weed pressure. If we deleted those subplots and focus on the 4 plant age classes with strong leaf growth, there was a significant linear decrease in leafminers per plant as plant age increased, in a pattern that was the same for both varieties, suggesting that the 2nd generation females were preferring younger plants regardless of variety as a place to lay their eggs.

We also evaluated 7 insecticides, including one for organic production, in leeks. In the controls (non-sprayed), 78% of the plants contained 1 or more leafminers (average 4.1, and reached 22 leafminers per plant). Of the 280 plants dissected across the whole trial, 18 exceeded 10, and 3 exceeded 20 leafminers per plant. We chose to limit timing and application methods to within labelled rates, which resulted in varying application timings among treatments, especially between foliar sprays and applications through drip irrigation. For the foliars, some had 6 applications about a week apart, whereas those with some systemic activity only had 4 applications with a wider spray interval. The drip options were limited to only 2 applications at a wide interval. Also, our drip applications used drip tape placed on the soil surface as opposed to buried closer to the roots. The leeks were very large by the time the 2nd generation flight occurred (standard size for a fall crop) and we started applications about 1 week after initial findings of adults.

The 2 foliar treatments (a diamide, Exirel, and a neonicotinoid, Scorpion) that we expect to have some systemic or translaminar activity reduced leafminer numbers compared to control. Surprisingly, drip applications with these same materials were not different than controls (but may have been due to position of drip tape mentioned above). When using a second measure, the number of damaged leaves, foliar applications of Scorpion and Radiant separated from controls. Considering both of these observations together, the neonicotinoid Scorpion was the only material that reduced both leafminer numbers and the number of damaged leaves per plot. An organic option (Aza-Direct), reduced pupal numbers, but not pupal + larval counts. Perhaps more frequent applications would show higher levels of control. We plan to redesign this study with drip tape placed closer to the roots and improved timings. Also, all of these insecticide approaches could differ markedly when working with onions or other alliums in the spring as opposed to large leek plants in the fall.

Growers have mentioned finding leafminer pupae in harvested crops even with a standard spray program. We were able to look at this in a variety planting of leeks that was managed as a commercial field regarding the application of fungicides and insecticides in the fall of 2017. Five insecticide cover sprays that varied active ingredients (Radiant (2x), Mustang Max, Exirel, Scorpion) were used in this planting and this schedule was effective in controlling allium leafminer. Compared to our 78% infestation rate in the controls of the leek efficacy trial, the leek variety trial had a 0.8% infestation rate (13 positives out of 1615 plants evaluated).

Farms with continuous crops of allium or with high populations of allium weeds are most likely to see damage from the allium leafminer. Small plantings can be protected with row covers applied before adult emergence but on a larger scale this is not practical. Fortunately, currently labelled insecticides will give satisfactory control of this insect, at least in a conventional production system. Additional studies need to be done to examine organic options for control. Allium leafminer infestation patterns are beginning to show a host-choice preference and/or variation in larval growth and survival among different allium species, varieties, and plant age. As these patterns become better defined they offer the promise for management with trap cropping methods.

We plan to continue working to gain a better understanding of the allium leafminer and its management including: (1) a better monitoring system to know when flights are occurring and (2) optimizing choices, application methods, and timing of insecticides (both systemic and foliar) for different crops and production systems - including options allowable for organic production.

THE ALLIUM LEAF MINER SITUATION IN NEW JERSEY – 2017

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In early April of 2017 RCE IPM personnel placed yellow sticky cards (black gridded) in known host crops for the allium leaf miner (ALM). Crops included established chive and leek plantings as well as spring plantings of onions and garlic at several sites in New Jersey (see Figure 1). Trapping was conducted at most sites again in the Fall of 2017.

In the spring, trapping of ALM was successful in that significant numbers of adults were trapped from chive plantings at several sites (Princeton, Hopewell and Milford) from the first through the third week of April. Only one ALM adult was trapped in another crop (garlic – Asbury). Early in the season, chive plantings (overwintered) are growing rapidly with abundant succulent tissue. This is apparently attractive to ALM adults, as numerous flies visible in this crop and feeding/egglaying scars were common, while little sign of activity was discovered in other overwintered crops like garlic and leeks. However, economic injury from this ALM generation seems negligible on chives. Growers reported no noticeable decline in crop quality despite marketing cut chive foliage that was likely infested to some degree. Bulbs are not sold, and are so numerous in plantings that residual damage by maggots would be difficult to spot.

Attempts at trapping ALM at the same site as in the spring and at additional sites in East Vineland in the fall season were unsuccessful. Despite identifying plots on several farms with active infestations, no adults were captured on sticky cards. This result is consistent with what colleagues from Cornell operating in the Hudson Valley reported. Infestations on fall chives, if present, were not significant. Several plantings of scallions in Mercer County, onions in Hunterdon and Ocean counties as well as volunteer garlic in Hunterdon county did have significant infestations. In the latter case, 68% of garlic plants sampled had live maggots in the necks approximately 1" above the bulb on the 25th of October (see figure 2). Interestingly, 100% of plants showing feeding/egglaying scars were infested, while 100% of plants without the scars were uninfested. This indicates that egglaying should be assumed when these scars are present, not just the occurrence of adult feeding. It is possible that chives are a preferred early spring host, while preference changes to larger leafed hosts during the second flight.

Site	Crop	Number Trapped (April)	(May)	Total
Princeton	Chive	37	2	39
Hopewell	Chive	29	3	32
	Onion	0	0	0
	Garlic	0	X	0
Milford	Chive	13	4	17
	Leek	0	X	0
Asbury	Garlic	1	0	1
Chester	Chive	29	0	29
	Leek	0	X	0
E. Vineland	Chive	0	0	0
	Leek	0	0	0

Figure 1. Spring ALM trap results. X= no traps present.

Figure 2. ALM maggot in garlic stem (R), and feeding/egglaying scars on leaf (L).

SWEET CORN TRIALS COMPARING NON-*B.t.*, *B.t.*, AND STACKED *B.t.* VARIETIES

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Corn earworm (CEW) is the primary ear-damaging insect in sweet corn production in the mid-Atlantic states, and is the principle driver of silk stage insecticide applications on this crop. In New Jersey, CEW moth populations are generally low, to very low from late May through mid-June. This is followed by a period through mid-July when CEW adults are nearly non-existent. This situation changes in August and September, with weather-aided migratory influxes of CEW moths from the lower Atlantic Coast states. IPM programs monitoring CEW moth numbers are able to provide critical information to growers so that they can adjust their silk stage insecticide applications in response to increasing pest pressure. In an effort to minimize insecticide applications during this later part of the season, many growers have opted to use sweet corn varieties that incorporate toxins from the soil inhabiting bacterium *Bacillus thuringiensis* (*B.t.*).

There are currently three types of *B.t.* sweet corn available commercially: Attribute® hybrids (expressing Cry1Ab toxin), Attribute® II hybrids (expressing Cry1Ab and Vip3A), both from Syngenta Seeds, and Performance Series™ hybrids (expressing the Cry1A.105 and Cry2Ab2 toxins) from Seminis Seeds. While all hybrid types provide excellent control of European corn borer (ECB), and fair (Attribute) to excellent (Performance, Attribute II) control of fall armyworm (FAW), the control of CEW has deteriorated rapidly and dramatically in *B.t.* hybrids as field resistance to Cry toxins has developed in that insect.

In response to increasing instances of poor CEW control in the mid-Atlantic region, and in order to better track regional changes in CEW field resistance to *B.t.* toxins in sweet corn, a multi-state sentinel plot study was undertaken in 2017 (see figure 1). *B.t.* sweet corn is an ideal crop with which to monitor resistance to these toxins because 1) the toxins are expressed at higher concentrations in sweet corn than in *B.t.* field corn, 2) we have years of data on CEW ear infestations in non-*B.t.* corn as a baseline for expected damage, 3) changes in infestation rates are easy to track because CEW is almost exclusively an ear infesting insect and 4) there are true isogenic hybrids among non-*B.t.* and *B.t.* varieties, meaning that the only difference between them is the inclusion/type of *B.t.* derived toxin.

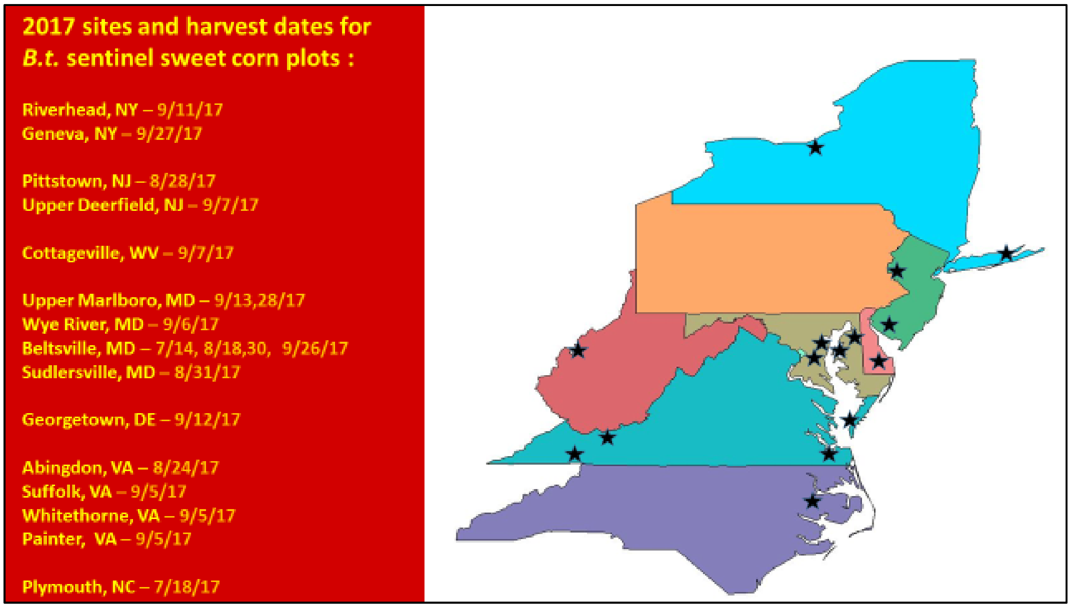

Figure 1. Sentinel plot locations in 2017

All field plots contained the isogenic bicolor hybrids ‘Providence’ (non-*B.t.*), ‘BC0805’ (Attribute - Cry1Ab) and ‘Remedy’ (Attribute II – Cry 1Ab, Vip3A). Plots at Upper Marlboro, Wye River and Beltsville, MD also contained the isogenic hybrids ‘Obsession’ (non-*B.t.*) and ‘Obsession II’ (Performance Series – Cry1A.105 +Cry2Ab2). Plots were planted such that the silking periods would fall in the later summer when CEW moth numbers were at their highest. No insecticide applications were made. All evaluations of ear damage occurred at fresh market maturity. Data recorded included number of ears damaged by CEW, size of surviving CEW larvae, kernel area consumed and proportion of larvae reaching later instars. Of greatest concern to growers is the number of ears damaged by CEW, which is what is addressed here.

Non-B.t vs. Attribute I vs. Attribute II

Although the earliest plot harvested (Plymouth, NC) and the northernmost sites (Pittstown, NJ, Riverhead and Geneva, NY) had lower CEW numbers overall, the trend was consistent throughout all sites. CEW field resistance to Cry1Ab toxin in sweet corn is widespread and significant enough that there is rarely a difference in CEW infestation between non-*B.t.* ‘Providence’ and Attribute I ‘BC0805’ except at the inland sites farthest north (see Figure 2). Even at these sites (Pittstown, NJ and Geneva, NY) however, ear damage by CEW would be considered unacceptable. At the same time, the Attribute II variety ‘Remedy’ shows at all sites that the Vip3A toxin is providing excellent control of CEW, with only a few individual surviving larvae over all locations. Sites followed by an asterisk (*) indicate multiple harvests. Figures at these sites are averages of two or more evaluations.

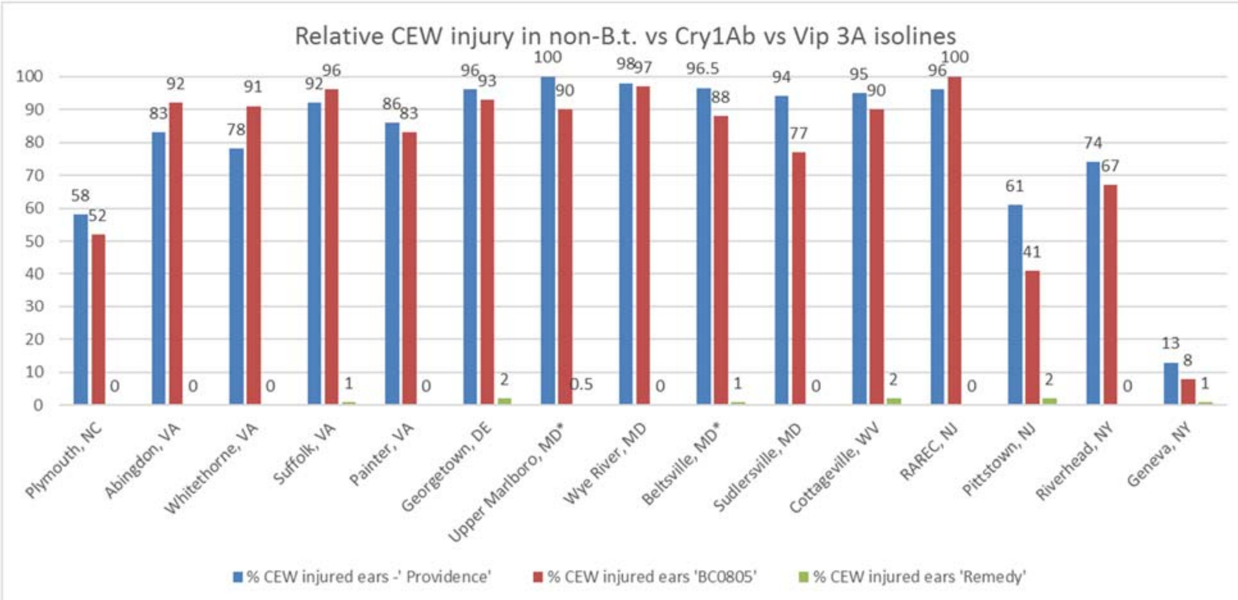

Figure 2. Ear damage from CEW – Attributer/Attribute II

Non-*B.t.* vs. Performance Series vs. Attribute II

The three sites in Maryland where 'Obsession II' (Performance Series – Cry1Ab, Cry 2Ab2) was paired with its' non-*B.t.* analog ('Obsession') showed that Cry 1Ab/Cry2Ab2 toxins no longer provide acceptable control of CEW (see Figure 3). Sites followed by an asterisk (*) indicate multiple harvests. Figures at these sites are averages of two or more evaluations.

Data from the 2017 study show that regionally, only varieties that incorporate the Vip trait (Attributer II) are providing excellent control of CEW without insecticide applications. Varieties that incorporate Cry toxins alone will require insecticidal intervention by growers at levels approaching that required on non-*B.t.* sweet corn. It bears repeating that all *B.t.* types to date are highly effective at preventing ECB injury at any growth stage, and Performance Series and Attribute II varieties provide excellent control of FAW as well. *B.t.* technology does not control sap beetles or corn leaf aphids. Because CEW populations in the southern U.S. are exposed to lower doses of *B.t.* toxins in field corn and cotton, they have developed strong resistance to them at the higher doses found in sweet corn varieties. This resistance is encountered in the Northeast U.S. later in the season because most of our CEW moths are migratory from points south. There appears to be a slight decrease in CEW ability to survive on sweet corn expressing Cry toxins in the northernmost (inland) sites in this study. This may be due either to susceptible individuals being more fit and able to migrate greater distances, or to mixing, with some individuals coming from areas where resistance has yet to develop to the degree is has in the southeast. Resistance trends will be monitored further, as refugia requirements in field corn have been relaxed. This may intensify resistance to *B.t.* toxins in CEW, and puts the Vip trait at risk for resistance development.

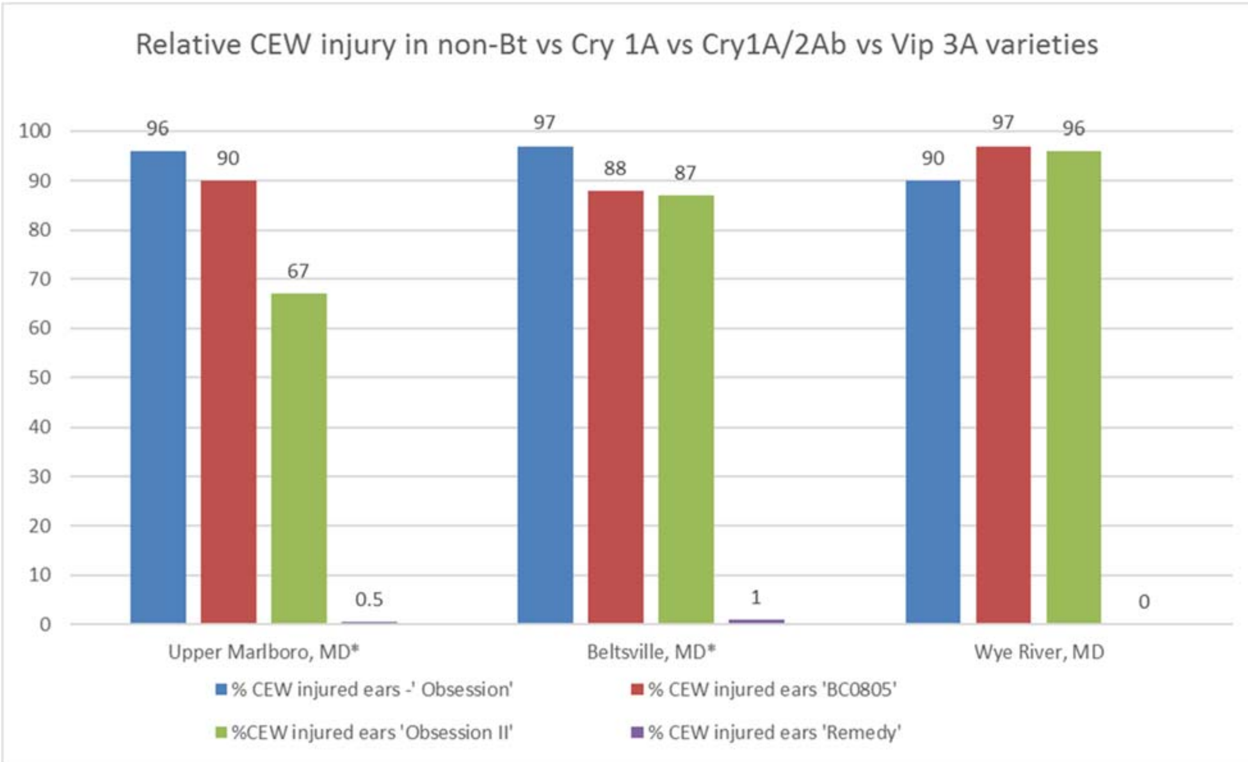

Figure 3. Ear damage from CEW – Performance Series

PEPPER WEEVIL, A CONTINUING PROBLEM

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Pepper weevil on fruit

Pepper weevil (Anthonomus eugenii) has become an annual pest for New Jersey pepper farmers. Prior to 2004, infestations occurred occasionally, sometimes years apart. Since the 2004 infestation at the Dennis Donio farm outside of Hammonton, we have continued to have nearly annual infestations occurring in different areas of southern New Jersey.

Infested produce brought into the state by food processors and repackers constitute the major pathway for introducing the weevil to New Jersey farms. Although the fruit may be infested it often does not appear damaged, because the developing larva(ae) inside don't always feed on the exterior wall of the pepper. Fruit on a grading line, though infested, may not be picked out and so is shipped out to other destinations. Anecdotal evidence suggests that terminal markets may also be a source of pepper weevils.

Life Cycle
Pepper weevils can go from egg to adult in 2 ½ to 3 ½ weeks, depending upon temperature; the warmer the temperature the more rapid is the development. The female can lay from about 200 to 400 eggs and prefers flowers or developing fruit for oviposition. The eggs are inserted into the pepper cuticle resulting in a dimple or blemish on the surface of the pepper. The white grubs turn grayish-white as they mature and feed usually in the core of the pepper. Once the grubs have matured they will be in the non-feeding pupal stage for about four to five days. The mature weevils chew holes in the pepper wall to escape the pepper. Pepper weevils do not have a diapause stage and so require a constant food source of solanaceous plants. Because of this requirement, the weevils cannot overwinter in New Jersey.

Damage
All pepper varieties are susceptible. Damage is largely the loss of yield. Young, infested peppers are usually aborted and is one of the symptoms of an infestation, that is, immature fruit lying on the ground. As the smaller fruit are aborted, the weevils will lay eggs in larger fruit that may not show the dimple caused by the egg scar. Larger fruit are less likely to abort and remain on the plant and are harvested.

Control

Aborted fruit with larvae

Pepper weevils are very difficult to control. Insecticide applications affect only the adult stage; immatures are protected by being inside the fruit. Systemic insecticides are ineffective because the infested fruit abort. Because of the short life cycle, many generations may occur through a growing season and the emergence of the adults is continual. With current insecticides, suppression is possible but the infestation will eventually encompass the entire field.

Current Situation

Beginning in 2014 one processing facility changed their processing schedule such that they no longer brought produce in from outside sources and began their operation only when local fruit became available. This helped greatly in reducing the incidence of escaped weevils. From 2014 to 2016 minor infestations were found late in the growing season but were of no consequence. In 2017, no infestations were detected until mid-August when an infested field was found in the Hammonton area. After that other farms in the area developed infestations. In total, as far as known, 6 farms became infested with estimated yield loss ranging from very little to significant.

This year (2017) it was discovered that one processing facility was making pepper waste available to farmers to use as a soil amendment. The pepper waste would be dumped, spread out and be incorporated into the soil. Pheromone traps were set, September 26, on the border of one of the fields where the pepper waste was being deposited. Between September 26 and October 11, 10 weevils were trapped on 3 pheromone traps. The field into which the waste was being dumped had been in field corn and the field was otherwise bordered by an orchard, fallow ground, and a woodlot. There were no pepper fields in the adjacent area that would have been a source for these weevils.

Although most of the pepper waste had been ground up, many, mostly intact fruit were visible in the piles.

Pepper waste dumped in field

Close-up of pepper waste

This practice of dumping pepper waste into fields increases the risk of developing pepper weevil infestations in pepper fields near the dumping field. Pepper farmers should be aware of this practice and know whether pepper waste is being used within 1 ½ miles of their fields.

Recommendations

The best way to manage pepper weevil for New Jersey farmers is to avoid getting an infestation.

Do not plant solanaceous crops within 1 ½ miles of a processing facility or repacker, if possible.

Clean off vehicles and produce bins that have come from a processing plant before coming back to the farm.

Monitor for the presence of weevils using pheromone traps.

Make an insecticide application when a weevil is trapped.

An insecticide application should be made at first flower to prevent an early infestation of weevils.

Wine Grapes

WEED MANAGEMENT DURING THE VINEYARD ESTABfLISHMENT

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Weeds remain a major challenge in newly planted vineyards. The effect of competition from weeds is most severe in the first three years of grapevine establishment, where competition can reduce cane growth and delay fruit production. Like for any other agronomic system, annual grasses and broadleaves account for most of the weed species. However, the lack of annual crop rotation and soil cultivation make vineyards more prone to the development of hard-to-control perennial weeds. Additionally, the number of herbicides labeled on newly planted vineyards is limited compared to established vineyards. Thus, efficient weed management strategies will rely on various control measures that need to be tailored to weed populations specific to your vineyard. This presentation will cover the basics of a successful weed management program from proper weed identification to the selection of appropriate tools to control weeds in newly planted vineyards.

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 similar to 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 (http://www.cornellpress.cornell.edu/book/) or weed identification websites (http://oak.ppws.vt.edu/~flessner/weedguide/) can be helpful to accurately determine weed species and become familiar with their biology and ecology. Weeds can be divided into three groups. Grasses are a single botanical plant family with jointed stems, leaves with parallel veins that are divided into a blade and a sheath that wraps around the stem. Sedges appear like grasses at a glance. Leaves are narrow with parallel veins, but they are not divided into a blade and sheath. Sedges have a distinctly triangular stem. Broadleaf weeds are a large collection of diverse plant families that have wide leaves, showy flowers, and seeds that are divided into two halves. Among these three groups, species can be subdivided based on their seasonality. Annuals are weeds that live less than a year. Summer annuals germinate in the late spring and early summer, flower and set seed in late summer or early fall and die when it gets cool. Winter annuals germinate in the fall or early spring, flower and set seed in late spring, and die when it gets hot. Biennials are weeds that live longer than a year, but less than 2 full years. Perennials are weeds that live longer than 2 years.

Prevention

The first step of any weed management program is to consider the steps that need to be taken to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species. The purchase of weed-free seeds when sodding the row middles, the necessity of cleaning equipment before moving from infested to non-infested fields, the use of weed-free irrigation water, the control of weeds on field borders and ditches, and prohibiting weeds already present from going to seeds are some of the key elements of an effective weed prevention program.

Weed Monitoring

Prevention is a necessary step but is not sufficient by itself. Weeds have generally to 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. Surveying weeds will help you determine if a change in herbicides or cultural methods is needed. In late winter, survey will help identify weeds that escaped from fall herbicide application and determine what herbicide needs to be applied in early spring. A survey in summer will tell you the spectrum of weeds present and determine the effectiveness of herbicides or cultivation practices. A late summer survey is useful to determine if a fall preemergence herbicide application is required. Keep records of your weed surveys to track weed population information from year to year to better understand ongoing weed control problems such as perennial weeds or herbicide resistance. 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 may extremely important with regards to chemical weed control. 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 Management before Planting

Weed control should be started even before planting grapevine. While total "weed-free" soil is not usually possible, growers should keep clean soil prior to planting by ridding the soil of weeds through a burndown herbicide application, a thick, suppressive cover crop mulch, or mechanical weed control such as tillage and cultivation. It is especially important to control established stands of perennial weeds before grapevines are planted. This will also reduce potential injury to young vines from herbicides that would have been used to control these perennial after the vines are planted. Field bindweed, Canada thistle, quackgrass, and yellow nutsedge are especially troublesome perennial weeds.

Preventing seed production of weeds already growing in the field through frequent soil cultivation will help reduce the soil weed seedbank and, consequently, weed density. Additionally, light cultivation followed by irrigation will stimulate the germination of some weed seeds contained in soil and repeated shallow cultivation will eliminate recently emerged seedlings. Seedlings of many perennials can be controlled by repeated cultivation.

For rhizomatic and tuberous perennial weeds, chemical control may be required to prepare the field before planting grapevine. Field bindweed growth can be reduced for up to two years by treating with a high dose of glyphosate or by deep plowing to cut the roots at a depth of 16 to 18 inches in dry soil. Nutsedge infestations can be reduced by deep plowing with large moldboard plows that bury the nutlets to a depth of at least 12 inches. Postemergence herbicides generally have little or no soil residual and are safer to use before planting vines. However, the use of preemergence herbicide is not recommended before planting as there is a risk of exposing newly planted vine's root to herbicide contained in the soil used to fill up the planting hole. This may result in severe grapevine injury.

Weed Management in New Vineyards

Complete weed control is critical the first two years following grapevine planting to ensure high survival rates and quick establishment as weed competition can dramatically slow growth of young plants. Regardless of the method used to control weeds, damage to the vine trunk or roots by chemicals and mechanical equipment should be avoided.

Non-chemical weed control usually requires hoeing, cultivating, or the usage of weed knives (set less than 2 inches deep around vines) several times during the spring and summer. Mechanical cultivators available for use in the vine row include weed knives, spyder cultivators, and rotary tillers. Rotary tillers such as a Weed Badger, Kimco, or Clements Hoe are most effective if used on loose soil free of large rocks. The equipment should be set to cut shallowly to minimize damage to vine roots. Mechanical control of weeds must be done repeatedly when weeds are small since mature weeds become more difficult to control, may clog equipment, and will produce seed.

Weed control on the row can also be achieved with mulch such as sawdust, wood chips or coarse leaf mulch applied three to four inches thick when the rows are weed free. The use of mulches such as straw is not recommended as these provide a favorable environment for rodents that may damage grapevine root and green bark. All organic mulches break down over time and tie up important nutrients, especially nitrogen, so the use of mulch may require additional fertilizer. Mulch should be reapplied annually or when needed to maintain weed suppression.

Chemical weed control has many advantages, including control and cost efficiency, safety when correctly used, and the elimination of crop and root injury caused by cultivation. Preemergence herbicide that are soil-applied before weed start to emerge can be sprayed in area three to six feet around each vine. Devrinol (napropamide), Chateau (flumioxazin), Gallery (isoxaben), Prowl (pendimethalin), Surflan (oryzalin), Goal (oxyfluorfen), and Solicam (norflurazon) are preemergence herbicides labeled for weed control on newly planted (non-bearing) vineyards.

Herbicides can also be applied to control weeds after they emerge and are usually referred as postemergence herbicides. Fusilade (fluazifop), Select (clethodim), and Poast (sethoxydim) are selective grass herbicides that will control recently emerged annual grasses in newly planted vineyards. To be effective, these grass herbicides require the addition of a nonphytotoxic oil or a nonionic surfactant. These materials do not control nutsedge or broadleaf weeds and clethodim is the only selective grass herbicide that will control annual bluegrass. Gramoxone (paraquat) can be used to control most weeds and grasses near young vines if they are protected with shields or wraps. The systemic herbicide glyphosate will control broadleaf weeds after emergence, but should only be used around mature vines that have brown bark or newly planted vines protected with waxed carton shields. Glyphosate should not be allowed to contact leaves or green shoots as substantial crop injury can occur. Follow all label precautions and directions, including requirements for protective equipment.

Weed management of the row middles can be done through the seeding of a dense sod that will compete with weeds but will require fifteen to twenty months to establish. During this period, it is critical to control broadleaf weeds growing in the sod. The flowers of dandelion, clover, mustard species and other weeds may coincide with bloom and are preferred by pollinating insects. The same weeds, and others, may also bloom before or after the crop blooms and attract bees into the field when insecticides must be sprayed. Clover can especially be difficult to control, but can be suppressed or controlled in a sod with good management practices that will favor grasses such as appropriate fertilization with nitrogen or mowing height no closer than four inches from the ground.

Weed Control Challenges

Perennial weeds remain difficult to control in vineyards. Special attention should be given to remove them from the field before planting grapevine as this is the ideal timing to safely control them with systemic herbicides and avoid damaging newly planted blueberries. Among the most challenging perennial weeds, yellow nutsedge (*Cyperus esculentus* L.) occupies a preeminent position given its specific life cycle. Although the weed can reproduce from seed, where it is established, annual re-infestation is primarily due dormant tubers (“nuts”) in the soil. Tubers can re-sprout six to eight times if cultivation kills the shoot. After the plant becomes established, rhizomes begin to grow in late spring, and by early to mid-summer, the rhizomes curve upward and produce additional plants. By August, the weed can sense the approach of fall by the longer nights, and a burst of rhizome growth follows. By early fall, a pronounced swelling can be observed at the tip of each rhizome, which matures into a new dormant tuber. Later in the fall, separation of the tuber from the rhizome will occur following mother plant death. Yellow nutsedge can be controlled by preventing new tuber production. This can be done by persistent control of nutsedge from late summer through early fall. The results of the effort will not be evident after one year. Too many “old” tubers remain dormant in the soil for several years before they sprout, but after several years, success will be evident.

WHAT WORKED WHAT DID NOT

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Planting:

1. Ground Prep:
    a. Soil test
    b. Soil Structure
    c. Soil Type
2. Variety/ Rootstock / Spacing:
    a. Vinifera
    b. French Hybrid
    c. American Native
3. Trellis materials:
    a. Poles
    b. Wire
    c. End Support
4. Grow tube materials / Plant Support materials:
    a. Plastic or Wax board (Milk carton)
    b. Metal, Wood or Bamboo
5. Irrigation Type:
    a. Over head
    b. Drip

Pruning / Training:

1. Tools
    a. Hand
    b. Tractor mounted
2. Style
    a. Grow up
    b. Grow down
    c. Training Materials

Weeding:

1. Chemicals:
    a. Burn down
    b. Pre emerge
    c. Equipment
2. Mechanical:
    a. Hand Tools
    b. Tractor mounted

Pest Control:

1. Sprayers
2. Timing
3. Materials
    a. Prevention
    b. Post event

Hedging:

1. Hand Tools
2. Tractor Mounted

Deleafing:

1. How much to pull and when:
    a. Post Bloom
    b. Pre Version
    c. Post Version
2. East side only or both:
3. Hand versus Tractor Mounted:

Finishing:

1. Crop size / Thinning
2. Bunch size
3. Bunch placement
4. Pink Bunch / Berry Removal

Peppers

UPDATE ON X10R AND PHYTOPHTHORA TOLERANT BELL PEPPER VARIETIES FOR USE IN NEW JERSEY

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Bacterial Leaf Spot

Bacterial leaf spot (BLS) caused by the pathogens *Xanthomonas euvesicatoria* and *Xanthomonas campestris pv. Vesicatoria* is the second most important disease on peppers in New Jersey. Phytophthora blight caused by *Phytophthora capsici* is the number one disease. Phytophthora continues to be a concern among growers, but with proper management and tolerance varieties growers are learning to live with the disease.

BLS on the other hand has become more of a concern over the last ten years. The pathogen is favored by high humidity, hard driving rains, vigorous plant growth, infected stakes and working in the field when plants are wet. There are eleven (0-10) races of BLS identified in the United States. Most commercial bell pepper varieties grown in New Jersey are resistant to races 1-3 which have been the main races found in the Northern United States. Until recently growers in New Jersey have managed BLS with a combination of resistant varieties and chemical control. In 2004, growers reported that resistant varieties were being infected with BLS. A series of screening trials were carried out to determine if other races may be present in the state. It was determined that race four was found in Southern New Jersey, but not in the Northern part of the state. Since 2004 varieties e.g. ‘Turnpike’, ‘PS0994-1819’, ‘Vanguard’ and ‘Tomcat’ have been released with resistance to race 4. There are no recommended cherry, sweet frying, hot or banana type peppers resistant to race 4. Bell pepper growers should continue to use a combination of resistant varieties and chemical control while specialty pepper growers only have management and chemical control.

In 2013, growers again noticed BLS showing up on varieties which were resistant to races 0-5. Differential studies were established to determine if additional races were present in New Jersey. Plots were setup in the Southern and Northern parts of the state with a series of varieties with resistance to different races from no resistance to resistances to all known races. As in previous differential studies, it was determined that other races were prevalent in South Jersey, but not North Jersey. The only varieties that did not express any symptoms were those resistant to all races. Races 6 and 10 could not be distinguished from one another since they are closely related and if there is resistance to race 6 there is resistance to race 10. This screening trial has been repeated twice with similar results.

In 2016 we started screening varieties and advanced breeding line for resistance to all races of bacterial leaf spot. In 2017 the trial was carried out in a grower's field where BLS has been a problem for several years. Plots were established on black plastic mulch with one drip line between double rows with distance between plants at 18 inches in double rows and 5 ft. between beds center to center. The plots were transplanted June 16. All cultural practices such as staking/tying, fertilization and pest management was carried out by the grower.

Based on seed company information, the entries '9325', 'CLX-1108', 'Tracer', 'Raven' and Prowler had resistance or intermediate resistance to all known races; 'Paladin' no resistance; 'Turnpike' resistant to 0-5 and 7-9; 'Revolution' resistant to 1-3 and 5. The plots were rated on a weekly basis for BLS by counting plants. The first BLS was observed on July 18 in the following entries (3 of 4 plots): 'Paladin', 'Turnpike', and 'Revolution'. By the end of the harvest season all entries except '9325' and 'CLX-1108' had BLS symptoms. All the symptoms were on leaves and none observed on the fruit during harvest.

The entries were harvested 5 times starting 54 days after transplanting from August 9 to September 29. Peppers were graded based on weight (extra-large >0.49 lbs., large 0.33 – 0.49 lbs., medium 0.25 – 0.32 lbs. culls >0.25 lbs.). Data is summarized in table 1 for all five harvests.

Table 1. Percent Marketable and Marketable Yield (28 lb. boxes) per Acre – 2017 - Vineland, NJ

Variety/Lines	X large	Large	Medium	% marketable	Total Marketable
Turnpike	997 a	556 cd	82 bc	98.6 a	1635 a
Prowler	615 c	761 ab	113 b	94.9 c	1488 ab
CLX-1108	637 bc	678 abc	119 ab	97.5 ab	1434 abc
Paladin	430 d	821 a	170 a	97.7 ab	1422 a-d
Revolution	804 b	490 d	47 c	96.5 bc	1341 bcd
Raven	610 cd	582 cd	94 bc	96.9 abc	1285 bcd
Tracer	562 cd	531 cd	81 bc	98.4 ab	1174 cd
9325	504 cd	603 bcd	57 c	98.3 ab	1163 d
LSD	**183.6**	**160.6**	**52.9**	**2.0**	**265.9**

Note: The same letters in the same column are not statistically different from one another.

‘Turnpike’ had statistically more boxes of extra large peppers and had the greatest number of total boxes per acre. However, for total boxes it was not statistically different from ‘Paladin’, ‘Prowler’, or ‘CLX-1108’. As mentioned above ‘CLX-1108’ showed no BLS symptoms by the end of the trial. The other entry with no symptoms had the lowest yield.

Cultural practices are also a concern when dealing with BLS e.g. disinfecting stakes, not working in the field when plants are wet, cleaning up fields when done harvesting and starting with clean seed. A grower cannot rely on just resistant varieties as we have seen over the last ten years BLS strains involve thus a compete disease management program is needed to produce a quality pepper.

Hot Water Seed Treatment

Seed hot water heat treatment is a good management tool for growers who save their own seed or purchase non treated seed. Most seed that is purchased is treated with chlorine which will control BLS if it is on the seed coat, but does not if the BLS is in the seed coat. Seed companies normally do not hot water treat pepper seed. There are several locations around New Jersey where growers can have their seed treated at Cooperative Extension Offices. Contact your local office for locations.

If a grower plans to treat their own seed care is needed or the germination could be affected. Two water baths are required with one for preheating (100°F for 10 minutes) and the second (125°F for 30 minutes) to the effective temperature to kill the bacteria. Immediately after removing the seed from the second bath it needs to be rinsed in cool water and dry dried. The seed can then be treated with a fungicide if desired. It is not recommended to treat pelleted seed since the pellet will dissolve. If primed seed is purchased do not heat it or the germination will be lowered. Any hot water treated seed should be planted that year.

Phytophthora Blight

Phytophthora has been a serious disease problem on peppers in New Jersey for at least 30 years. There has been only one variety (‘Paladin’) that has shown resistance in South Jersey since it was released in 1997. The resistance in ‘Paladin’ is breaking down in South Jersey. No matter what variety is grown, it must be combined with proper crop management. This starts with a good rotation program which is one of the biggest issues in South Jersey. Rotation of a vine crop, peppers and tomatoes is not a rotation. Rotation will not solve the problem, but is an important component of the management plan. This should be followed with planting on raised beds, good drainage between and the end of rows and chemical control. The bottom line with Phytophthora is growers need to learn to live with and manage it.

Each year a screening trial is held to evaluate new varieties and breeding line for Phytophthora tolerance, fruit quality, yield and the amount of silvering (skin separation).

This year nine entries with ‘Camelot’ as the susceptible control were trialed. In table 2 the yield per acres (28 lb./box) and percent silvering are presented. There was no phytophthora fruit rot at harvest. Plant stands were reduced from phytophthora which will be discussed at the meeting.

The entries were harvested 5 times from August 28 to October 18. Peppers were graded based on weight (extra-large >0.49 lbs., large 0.33 – 0.49 lbs., medium 0.25 – 0.32 lbs. culls >0.25 lbs.). Data is summarized in table 2 for all five harvests.

‘Revolution’ had the highest marketable yield and was statistically different from ‘Camelot’. One of the advanced breeding lines Seminis 4233 had statistically lower yields than ‘Camelot’. All the other entries were not statistically different from ‘Camelot for marketable yield. The percentage of silvering was below ten percent for all entries except ‘Turnpike’ and ‘Tomcat’. ‘Prowler’ had no silvering over the whole season.

Table 2. Marketable Yield (28 lb. boxes) per Acre and Percent Silvering – 2017- Rutgers Agricultural Research and Extension Center, Bridgeton, NJ

Variety/Lines	X large	Large	Medium	Total Marketable	% Silvering
Revolution	117 bc	708 a	297 ab	1122 a	3.5 cd
Declaration	140 b	674 a	244 a-d	1057 ab	5.5 bc
Turnpike	263 a	539 ab	201 bcd	1003 ab	10.9 a
CLX-1108	63 bc	463 bc	282 abc	808 bc	3.0 cd
Camelot	33 c	432 bc	313 a	779 bcd	1.3 cd
Tomcat	66 bc	345 bcd	213 a-d	624 cde	10.6 a
Prowler	42 bc	311 cd	183 cd	536 cde	0.0 d
Seminis 4231	41 bc	271 cd	170 d	481 de	8.9 ab
Seminis 4233	22 c	166 d	161 d	349 e	4.3 bcd
LSD	**101.9**	**207.8**	**102.9**	**306.6**	**4.8**

Note: The same letters in the same column are not statistically different from one another.

CONTROLLING IMPORTANT PEPPER DISEASES

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Controlling anthracnose fruit rot.

Anthracnose fruit rot has been an increasing problem in pepper production during the past few years. The pathogen, *Colletotrichum* spp., also causes a fruit rot in strawberries and tomatoes. The pathogen can infect pepper during all stages of fruit development resulting in serious losses if not controlled properly. Symptoms of anthracnose fruit rot include sunken (flat), circular lesions. In most cases, multiple lesions will develop on a single fruit. As lesions enlarge, diagnostic pinkish-orange spore masses develop in the center of lesions. During warm, wet weather spores are splashed onto healthy fruit through rainfall or overhead irrigation.

Managing anthracnose fruit rot begins with good cultural practices. The pathogen overwinters on infected plant debris and other susceptible hosts. The fungus does not survive for long periods without the presence of plant debris. Pepper fields should be thoroughly worked (i.e., disced, plowed under) after the season to help break down and bury old debris. Heavily infested fields should be rotated out of peppers for at least three years. Do not plant or rotate with strawberries, tomatoes, eggplant or other *solanaceous* crops. Once areas in fields become infested, management of the disease can be difficult. Prevention is critical to controlling anthracnose fruit rot.

Beginning at flowering, especially if fields have had a past history of anthracnose.

Alternate:

chlorothalonil (FRAC group M5) at 1.5 pt/A or OLF, or
Manzate Pro-Stik (M3) at 1.6 to 3.2 lb 75DF/A

with a tank mix of chlorothalonil at 1.5 pt/A plus one of the following FRAC code 11 fungicides:

Quadris (azoxystrobin, 11) at 6.2-15.0 fl oz 2.08SC/A, or
Cabrio (pyraclostrobin, 11) at 8.0-12.0 oz 20EG/A, or
Priaxor (boscalid + pyraclostrobin, 7 + 11) at 4.0 to 8.0 fl oz 4.17SC/A.

With a tank mix containing chorothalonil at 1.5 pt/A or Manzate Pro-Stik at 1.6 lb/A and one of the following FRAC code 11 fungicides:

Quadris Top (azoxystrobin + difenconazole, 11 + 3) at 8.0 to 14.o fl oz 1.67SC/A
Aprovia Top (difenconazole + benzovindiflupyr, 3 + 7) at 10.5 to 13.5 fl oz

Prevention is critical to controlling anthracnose fruit rot. Infected fruit left in the field during the production season will act as sources of inoculum for the remainder of the season, and therefore, should be removed accordingly. Thorough coverage (especially on fruit) is extremely important and high fertility programs may lead to thick, dense canopies reducing control. Growers have had success in reducing the spread of anthracnose by finding 'hot spots' early in the infection cycle and removing infected fruit and/or entire plants within and immediately around the hot spot.

Controlling Phytophthora crown and fruit rot.

Phytophthora blight (*Phytophthora capsici*) is one of the most destructive soil-borne diseases of pepper in the US. Without proper control measures, losses to Phytophthora blight can be extremely high. Heavy rains often lead to conditions which favor Phytophthora blight development in low, poorly drained areas of fields leading to the crown and stem rot phase of the disease. Infections often occur where water is slow to drain from the soil surface and/or where rainwater remains pooled for short periods of time after heavy rainfall. Always plant phytophthora-resistant/tolerant cultivars, such as Paladin, Aristotle, Turnpike, or Archimedes to help minimize losses to the crown rot phase of the disease. For an updated cultivar list please see the 2016 Commercial Vegetable Recommendations Guide.

For control of the crown rot phase of Phytophthora blight, apply:

Ridomil Gold (mefenoxam, 4) at 1.0 pt 4SL/A or 1 Ultra Flourish (mefenoxam, 4) at 1.0 qt 2E/A, or MetaStar (metalaxyl, 4) at 4.0 to 8.0 pt/A. Apply broadcast prior to planting or in a 12- to 16-inch band over the row before or after transplanting. Make two additional post-planting directed applications at 30-day intervals. Mefenoxam is still effective against sensitive populations of the pathogen. However, DO NOT USE mefenoxam, if mefenoxam-insensitive strains are present on your farm.

Ranman (cyazofamid, 21) at 2.75 fl. oz 400SC/A may be applied via transplant water (see label for restrictions)

Presidio (fluopicolide, 43) at 3.0 to 4.0 fl oz/4SC/A can be applied via drip irrigation (see supplemental label); PHI: 2 days

For prevention of the fruit rot phase of Phytophthora blight, alternate the following on a 7 day schedule:

Ridomil Gold Copper (mefenoxam + copper, 4 + M1) at 2.0 lb 65WP/A.
with one of the following materials.

Presidio (fluopicolide, 43) at 3.0 to 4.0 fl oz 4SC/A plus fixed copper at labeled rates
Revus (mandipropamid, 40) at 8.0 fl oz 2.08SC/A plus fixed copper at labeled rate
Ranman (cyazofamid, 21) at 2.75 fl oz 400SC/A *plus* a non-ionic surfactant
Forum (dimethomorph, 40) at 6.0 oz 4.18SC/A plus fixed copper at labeled rate.
Zampro at 14.0 fl oz 535SC/A plus fixed copper at labeled rate.

Tank mixing one of the above materials with a phosphite fungicide (FRAC code 33), such as K-Phite, Rampart, or Prophyt will also help control the fruit rot phase of Phytophthora blight.

Managing bacterial leaf spot in pepper

Bacterial leaf spot (BLS) in pepper has increased in some areas of the mid-Atlantic region over the past few years. There are ~10 races of the pathogen and in the past few years races 1,2,3,4,5 and 6 have been detected in New Jersey. The pathogen can be seed-borne and can cause significant problems in the field if transplants are exposed to the pathogen during transplant production. Hot water seed treatment can be done to help mitigate potential problems due to BLS. Any seed suspected of carrying BLS should be hot water treated, this is especially important in heirloom varieties or organic seed where BLS problems have been suspected or an issue in the past. Some of the most commonly-grown commercial bell and non-bell pepper cultivars in the region carry resistance packages to different races of the pathogen (see Table below). Many of the bell peppers grown in the region also have resistance/tolerance to phytophthora blight. Growers with past histories of BLS and/or phytophthora on their farm should only grow those cultivars that carry resistance/tolerance to both pathogens.

BELL PEPPER

Cultivar	BLS race resistance	Phytophthora Resistance/Tolerance
Paladin	none	R/T
Aristotle	1,2,3	R
Archimedes	1,2,3	T
Turnpike	1-5,7,9	T
Declaration	1,2,3,5	T
Revolution	1,2,3,5	T
1819	1,2,3,4,5	T
Intruder	1,2,3	T
Tomcat	1,2,3,4,5	none
Playmaker	0-10	T

EXOTIC PEPPER RESEARCH AND DEVELOPMENT UPDATES, 2017

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Abstract: In 2017 our exotic pepper work focused on: a) regular habanero pepper performance in conventional and organic plots; b) performance of super-hot peppers (super-hots); and c) evaluation of new selections including sweet minibell ("snack") peppers, New Mexico Cayenne pepper, the Padron and three jalapeno types (Sweet no-heat, Sweet mild-heat, and Hot cracked skin). We conducted all the studies at Horticultural Farm III, 67 Ryders Lane, East Brunswick, NJ. Nine of our top regular habanero selections (Hab A, B1, C, D, F, H, I, YH2, and YH3) were compared on the basis of life cycle, plant size, fruit yield and hotness. Similar data were collected on six super-hots (Carolina Reaper , Trinidad Scorpion, Bhut Jolokia, Carolina Reaper Segregants 1, 2, and 3). The "snack" peppers were compared based on life cycle, yield and taste. For marketing purposes all the regular habanero and snack peppers were subjected to visual evaluation by (54) participants at the 2017 Harvest Your Own Pepper (HYOP) event. Available results showed the following:

a) ***Regular habanero evaluation***: Based on life cycle, the regular habs were classified into early, medium, and late maturing types as follows: early maturing -- Hab H &YH3; medium maturing -- Hab B1, C, D, F, I & YH2; late maturing - Hab A. Based on plant size they were classified into small, medium and large size plants as follows: small --- Hab H & YH3; medium – Hab B1, C, F, I & YH2; large – Hab A &D. On fruit yield basis they were classified into high, medium and low yielding types as follows: high yielding – Hab B1, C, D, F, H, I, & YH3; medium yielding – Hab YH2; low yielding – Hab A. As expected, the regular habs varied significantly in the degree of hotness due to the capsaicin alkaloids, as quantified using HPLC. Based on hotness using the Scoville Heat Units (SHU) the regular habs were classified into mild and hot categories as follows: mild – Hab I & YH3; hot – Hab A, B1, C, D, F, H, &YH2. The culture medium either organic or conventional had no significant impact on heat level in the regular habs (Figure 1).
b) ***Evaluation of super-hots:*** The super-hot peppers had life cycles that were comparable to that of the regular habs. The six selections evaluated were medium maturing but the Bhut Jolokia and Carolina Reaper (CR) flowered first

while the Trinidad Scorpion flowered last and was classified as Medium/Late maturing. The Trinidad Scorpion exhibited the largest plant size and the rest had medium size. The super-hot peppers were low to medium yielding, with Bhut Jolokia, Carolina Reaper and CR Segregant 2 producing the highest yield while the Trinidad Scorpion produced the lowest yield. Carolina Reaper Segregant 1 also produced medium yield, but the smooth skin of the fruit set it apart from the other super-hots. The yield from CR Segregant 3 was in between the medium and low yielding super-hots. The Scoville Heat Unit analysis showed CR as the hottest of all the super-hots with a SHU of >1.3 million followed by CR Segregants 2 &3 and the Trinidad Scorpion. The Bhut Jolokia (Ghost pepper) expressed only 0.6 million SHU, which was significantly lower than the 1 million SHU it was globally known to exhibit.

c) ***Evaluation of "snack" peppers and new selections*****:** Sweet minibell (snack) peppers (the Yellow Honey, Red Candy, and Sweet Orange) all performed well in 2017 in organic and conventional plots. On life cycle basis, they were classified as early maturing and plant sizes ranged from small to medium. On yield basis they were all high yielders. The New Mexico Cayenne #1 is very late maturing but an exceptionally high yielding pepper. The Padron pepper (similar to Poblano peppers) was early maturing and high yielding. It also has an exceptionally favorable ripe fruit durability (RFD) which allows a flexible harvesting schedule. The sweet no-heat jalapeno (SNHJ), sweet mild heat jalapeno (SMHJ) and hot cracked skin jalapeno (HCSJ) were all early maturing, had small size plants and high yielding. Scoville heat unit analysis showed zero to very low heat level in the snack peppers, the New Mexico cayenne, Padron pepper and the Jalapeno peppers. These new pepper selections will be further developed to target the market niche for sweet tasting and low heat peppers.

d)

e) ***Visual evaluation of pepper fruit:*** On October 26, 90 people participated in the 2017 Harvest Your Own Pepper (HYOP) event. Out of the 90 people, 54 completed the pepper evaluation form, which requested the participant to rate the displayed peppers on general appearance and texture. Fourteen pepper selections were displayed (10 habaneros, 3 sweet minibells and 1 specialty pepper-Bishop crown). Of the 14 peppers Hab A, YH3 (Pumpkin Habanero) and H (Naveled habanero) were picked as the top three most attractive selections in that order. This evaluation practically confirmed past surveys, which had repeatedly selected these three habaneros as the most attractive. Going forward in our future pepper research, this visual evaluation results will continue to guide our selection of the habanero peppers to promote in our community.

Conclusion: Based on several criteria used to evaluate all the peppers in our 2017 field work we have advanced our understanding of how to proceed in the future with targeting various market niches in New Jersey for exotic peppers for the fresh and processing markets. By combining field performance and phytochemical data, our decisions are much stronger as we tie together the feasibility for field production and the ultimate nutritional and health values of the exotic peppers we promote in our communities. Other aspects of the exotic pepper project include the study of the quality of hot sauces produced from the different peppers in our collection. Currently a pepper sauce company is collaborating with us to determine the quality of hot sauces from our major regular habs. We shall add the results to our presentation if these are known before the February meeting.

Acknowlegement; We remain indebted to Rutgers NJAES for providing the funds to sustain the exotic pepper work. We also acknowledge the support provided by all of our field and technical staff at the NJAES research stations where we conduct our studies. Several undergraduate and graduate interns have contributed immensely to data collection and field management. We are grateful to them all.

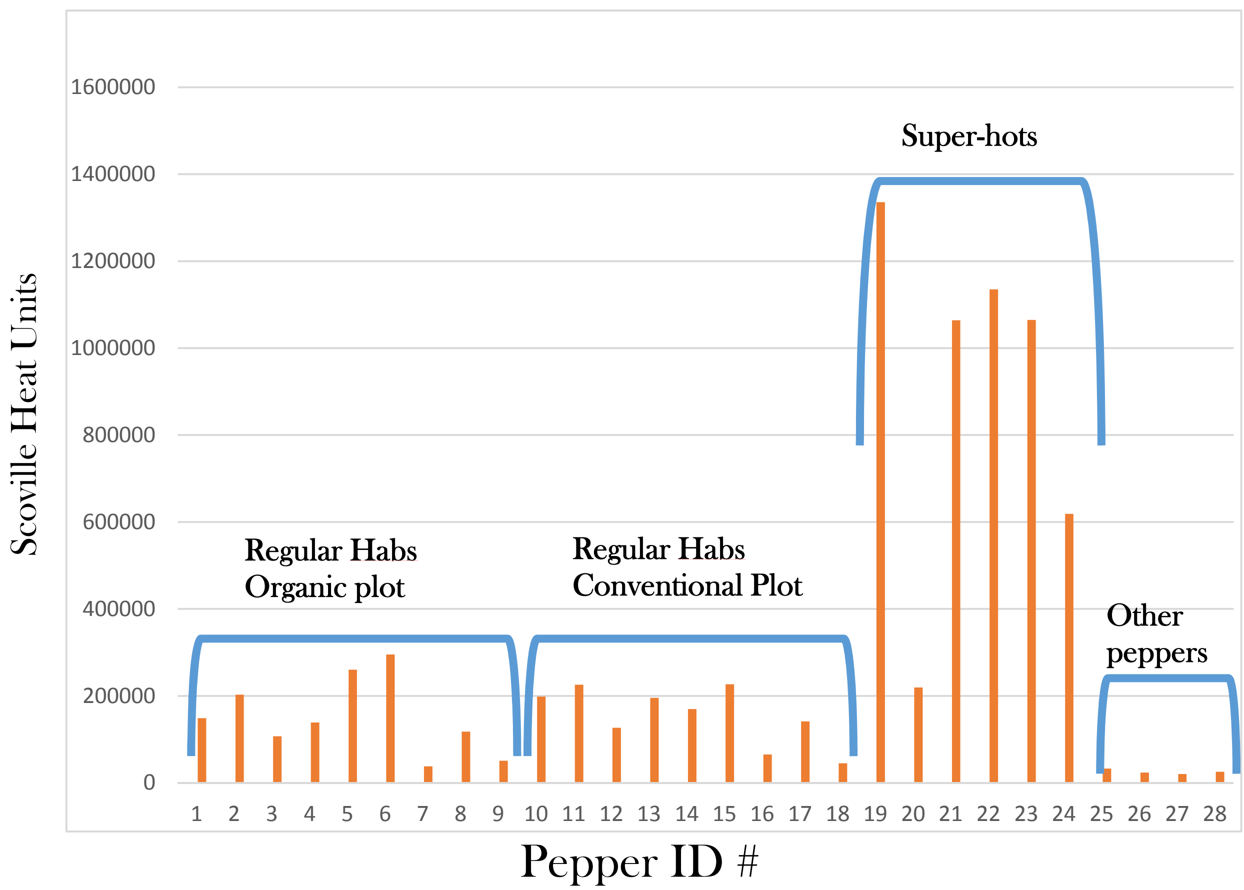

Figure1: Scoville Heat Units for regular habanero peppers (organic & conventional plots), super-hots and other peppers at Hort Farm 3

Food Safety

CHOOSING AND USING PRODUCT CONTACT SURFACE SANITIZERS

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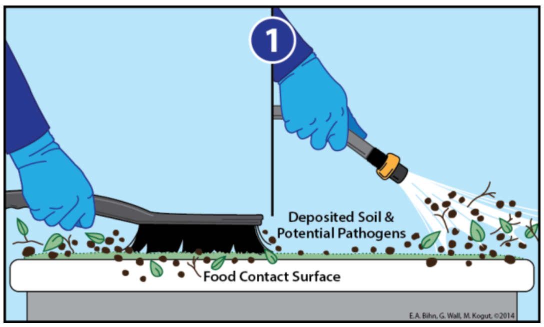
There are many ways that product contact surfaces can come to harbor human pathogens. Normal production of fresh produce involves the potential for contact with soil, farm workers, harvest and packing equipment, irrigation water and postharvest water to name a few. Once contaminated these items, considered food contact surfaces, can spread the pathogen onto the produce that it touches. Contact surfaces vary from farm to farm, the easiest way to identify them is to trace produce from the field to the sales location identifying each surface along the way. Direct marketers need to consider the potential risk with pick-your-own containers, product displays, and shopping containers and bags. Product contact surfaces must be washed, rinsed and sanitized regularly to reduce the likelihood of human pathogen contamination. Surfaces that come in contact with produce must be easy to assess for cleanliness, easy to clean and easy to sanitize. This may require you to take apart the equipment, particularly if conveyers, rollers or brushes are components.

Human pathogens, such as *E. coli*, Salmonella and Listeria, can grow on surfaces when the environmental conditions are appropriate. These pathogens thrive, and reproduce, in moist conditions. Smooth surfaces are much easier to clean than rough surfaces, and wood cannot be sanitized. Keep in mind that even stainless steel surfaces can harbor pathogens if not cleaned and sanitized properly. A regular cleaning schedule must be developed utilizing appropriate cleaners and sanitizers. Standard operating procedures (SOPs), or detailed instructions, must be written and posted describing how and when the cleaning and sanitizing produces will take place.

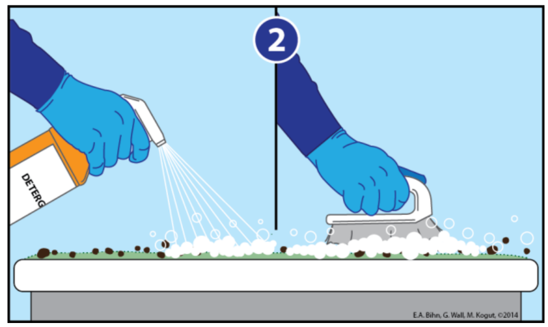
Picking a sanitizer

There are many sanitizers available on the market for use, including approved for organic use sanitizers. Options include chlorine, peroxyacetic acid, quaternary ammonium, hydrogen peroxide and others. Using too little of a sanitizer is ineffective, and too much of a sanitizer can cause damage to the surface you are cleaning. Consideration should be given to compatibility of the surface to be sanitized with the sanitizer. Incompatibility can reduce the effectiveness of the sanitizer and degrade the surface. This is also true for the detergent used to clean the surface. Label instructions should give guidance on what detergents are acceptable for the sanitizer. Be sure to read labels of the sanitizers, often available online, prior to purchase. Each sanitizer will have its own instructions for use, which can vary considerably.

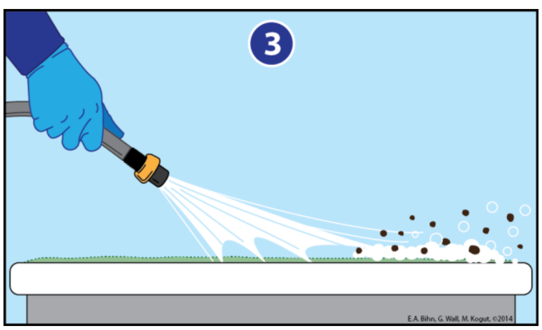
What is proper cleaning and sanitization of product contact surfaces?
Cleaning is the removal of dirt from surfaces which uses clean water and detergent. Sanitizing is the treatment of a cleaned surface to reduce or eliminate microorganisms. Dirty surfaces cannot be sanitized, the soil can render the sanitizer ineffective. Cleaning must take place before sanitization. Always use clean water that is free from generic *E. coli* for all cleaning and sanitizing steps.



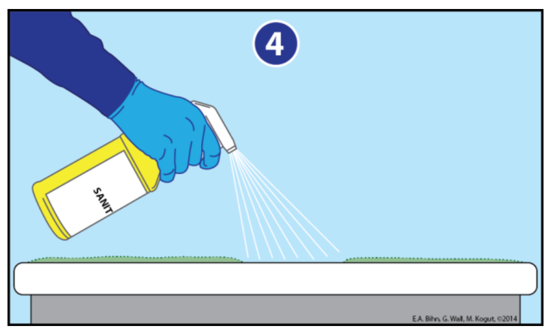
Step 1: Remove any obvious dirt and debris from the food contact surface.



Step 2: Apply an appropriate detergent and scrub the surface.



Step 3: Rinse the surface with clean water, making sure to remove all of the detergent and soil.



Step 4: Apply a sanitizer approved for use on food contact surfaces. Rinsing may be necessary Let the surface air dry.

Critical points to consider:

- Only use sanitizers that are approved for food contact surfaces, and follow the label directions exactly.
- Develop a regular cleaning schedule with a written SOP detailing the products used, how they are used, and the steps involved in cleaning and sanitizing the surfaces. Daily sanitizing is best!
- Utilize smooth surfaces that cannot absorb water as your product contact surfaces, wood can be covered with linoleum or painted with food grade paint.
- Avoid cracks and crevices in your packing areas, these are difficult to clean and sanitize.

- Train workers annually on Worker Health and Hygiene, including proper handwashing.
- Train workers annually on the importance of sanitation and the farms developed SOPs.
- Workers must wear clean clothing daily.
- When gloves are used workers must be trained on how to use them so they do not become a contamination source.
- Remove surface moisture in the packinghouse/area whenever possible using squeegees and fans.
- Remove culls from the packing area daily so they do not become an attractant for wildlife.
- Utilize a pest control program in the packing and storage areas, focusing on rodents and other wildlife intrusions.
- Remove as much soil as possible from produce in the field, not in the packing area.
- Use new containers or containers that can be cleaned and/or sanitized to pack and display produce.
- Storage areas and coolers should be monitored for cleanliness, and be included in the rodent control program.

Resources:

Sanitation and Postharvest Handling. National Good Agricultural Practices Program, Cornell University. 2016. https://gaps.cornell.edu/educational-materials/decision-trees/sanitation-and-postharvest-handling

Small Scale Postharvest Handling Practices. University of California, Davis. 2003. http://ucce.ucdavis.edu/files/datastore/234-1450.pdf

*Photos curtesy of the Produce Safety Alliance

FSMA PRODUCE SAFETY RULE: TIMELINE, INSPECTIONS, CHANGES AND RESOURCES

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Food Safety Modernization Act Timeline:

The Food Safety Modernization Act (FSMA) was signed into law January, 2011. The final rule was published November 2015 after comment periods and public meetings. This is the biggest change to food safety that directly impacts fresh fruit and vegetable growers in over 70 years. The Act will be implemented over the next several years with compliance for growers with annual produce sales (previous three-year period) over $500,000 starting in January 2018, small operations ($250,000 – $500,000) January 2019 and the very small operation ($25,000 – $250,000) January 2020. All operations will have four additional years for the water component and some recordkeeping. Growers with produce sales 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, sold from the farm is less than $500,000 averaged over the last three years (adjusted for inflation based on 2011 dollars), goes directly to an end user (restaurant, 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, etc.

Growers should be aware that a buyer may still ask 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 whom buys your produce.

Inspections:

The New Jersey Department of Agriculture (NJDA) will be carrying out the inspections for the U.S. Food and Drug Administration (FDA). Originally the inspections were to start in January 2018, but inspections will be delayed until January 2019 for the largest operations (over 500,000 dollars). The other size operations will also be delayed by one year i.e. 2020 for small operations and 2021 for very small operations. The first .

inspections will be educational with the NJDA evaluating the farming operation. This will give the grower an opportunity to see what the NJDA considers area where improvement may be needed. After the inspection NJDA may do another inspection with possible enforcement in the future.

On-Farm Readiness Review:

The Food and Drug Administration is interested in helping growers with tools that they can use for a self-assessment prior to any inspections from NJDA. They want to educate before regulating and work in a partnership with growers and the individual states. We have been working with the National Association of State Departments of Agriculture (NASDA) and four state departments of agriculture (Oregon, North Carolina, Florida and Vermont) the Food and Drug Administration (Produce Safety Office of Regulatory Affairs, Inspectors), United States Department of Agriculture (FDA liaison and GAP auditors), Cooperative Extension Organizations in Michigan, Florida, North Carolina and the Produce Safety Alliance at Cornell University to develop materials for growers to help them prepare for an inspection.

We have developed the On-Farm Readiness Review manual 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. Part of the OFRR is a farm visit where someone from Cooperative Extension and NJDA will team up to help growers assess their operations. This will start in 2018 and continue as needed.

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

- prepare farmers 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 farmers assess their readiness for implementation of the FSMA PSR, and
- provide the tools to help assess how prepared an individual farm is to implement the rule.

There are numerous reasons why a grower might want to undertake an OFRR:

- It is voluntary and free.
- It will help them align what they are doing with what is required in the rule.
- It will help them determine what they are missing.
- 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 regulations.” Our 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 farmers, 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.

We hope the manual will be a useful and workable tool for growers, extension and inspection staff to use 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. Growers who go through the OFRR will receive a manual during the farm visit.

Resources

There are many resources available to help growers comply with FSMA.

https://producesafetyalliance.cornell.edu
The Produce Safety Alliance is the main resource for information on the Produce Rule. They have developed training materials, guides and webinars that explain different parts of the rule.

https://www.fda.gov/Food/GuidanceRegulation/FSMA/default.htm
The Food and Drug Administration website has the full text of the final rules, posts of any changes and has a place to ask questions for interpretation of the rules.

http://plant-pest-advisory.rutgers.edu/category/commercial-ag-updates/food-safety/
This is the source of information that we publish for the industry in New Jersey. It also is the location for all our training materials.

https://www.uvm.edu/extension/necafs
The Northeast Center to Advance Food Safety is a collaboration among 12 states which aims to improve food safety among the region’s small and medium sized growers.

Alternative Crops

CARING OF FIG TREES

William Muzychko
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Mr. Muzychko is the founder and owner of Bill's Figs located in Hunterdon County, New Jersey. At Bill's Figs he manages every stage in the life of a fig tree including the planting, growing, picking, pruning and winterization of every tree he grows. He now has over 200 varieties of fig trees with even more in development.

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

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

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

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

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

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

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

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

4. **Trimming.** You should trim the tallest branches of your tree back by up to one third of their length before you bring it indoors. Do not worry. You cannot make a mistake. Fig trees love being cut back and 3 or 4 new branches will appear the next year where you cut the branch back. And figs develop on the near year's growth so your trimming will bring you a larger crop. If you want to keep the tree its present size for over wintering storage or to make it easy to move, trim it to your needs in the fall. Your tree can be moved with a standard hand truck initially and then with a fig mover (see Bill).

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

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

HAZELNUTS FOR COMMERCIAL PRODUCTION IN NEW JERSEY

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Attempts to establish hazelnut orchards in the northeastern United States date back to Colonial times. These efforts were continually stymied by a stem cankering disease called Eastern Filbert Blight (EFB). This disease, caused by the fungal pathogen *Anisogramma anomala*, is native to the region of the United States east of the Rocky Mountains and is only deadly to the European (commercial) hazelnut species *Corylus avellana*. In the 1800s, the Pacific North West (PNW) was a promising location to cultivate hazelnuts and by late that same century, a hazelnut industry was established in Western Oregon. The industry thrived for many years until the disease was introduced to Oregon and devastated the PNW hazelnut growing region. At this time, a hazelnut breeding program was established at Oregon State University with a focus on breeding for resistance to EFB. Approximately 30 years later, an additional breeding program was established through the New Jersey Agricultural Experiment Station (NJAES) with the additional goals of breeding for traits such as cold hardiness. Presently, 15 sources of resistance to EFB have been identified and are held in the germplasm collection at the NJAES hazelnut breeding program. Several of these EFB resistant breeding selections have been moved into the lab for tissue culture propagation. New Jersey, and the northeast as a whole, is on the cusp of finally establishing another hazelnut industry/growing region in the United States.

The steady progress of the NJAES breeding program has aligned with the exponential increase in demand for hazelnuts in the United States. These strides in the development of tools to build a hazelnut industry in the northeast have left huge opportunities for growers in the region to capitalize on a brand new, unique and potentially lucrative crop. This presentation will provide an outline of considerations for growers interested in establishing a hazelnut orchard on their farm.

The core of the discussion will involve details on how to establish, grow and harvest hazelnuts. Information will be provided on the best sites at which to establish a hazelnut orchard, preferred soil types, and suggested fertilization regimes. Brief descriptions will be provided on the species and cultivars of hazelnuts that can currently be purchased, as well as pollination considerations when choosing different species and cultivars. In addition several pruning methodologies and which are likely to be best adapted to different growing regions/cultivation practices will be illustrated. Details on the different harvest methods and equipment will be provided. Finally, the potential for marketing this new crop will be discussed briefly, along with background on the co-op networks that has been developed to aid in the marketing of hazelnuts in the PNW.

SMALL SCALE COMMERCIAL OYSTER MUSHROOM CULTIVATION INDOORS AND IN GREENHOUSES

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Abstract

Oyster mushrooms are highly marketable wild mushrooms that have been domesticated and adaptable to a wide range of growing substrates and growing room conditions. Chelsea Green author Tradd Cotter teaches this in-depth class on how to start, where to source materials, and the cultivation steps for all oyster mushrooms as well as a few other species that also grow on the same substrates. Using strategies for high yielding processes with low to no tech startup budgets, this class will synergize your plant and fungal relationships and focus on production for area markets

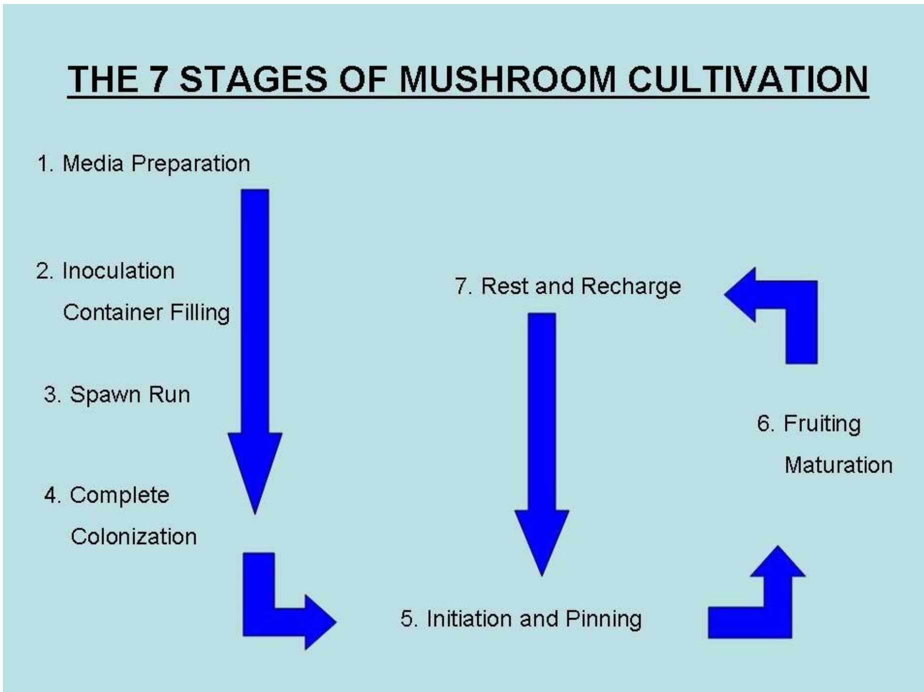
SUMMARY

Introduction

Mushrooms can be cultivated on a variety of food sources from manure to logs to a wider ranging wealth of agricultural byproducts such as cereal straws, dried bean hulls and shells, and sawdust of most hardwood tree species. Oyster mushrooms are the most versatile and forgiving, extremely fast fruiting (2-3weeks), and have an excellent market value for local producers. Choosing a type of oyster mushroom is dependent on your climate and growing environment, and since oyster mushrooms come in many colors and ecotypes that fruit at different temperatures, almost anyone can put together a plan to cultivate these wonderful mushrooms year-round in modified or existing structures such as barns or greenhouses. Mushrooms create HEAT, CARBON DIOXIDE, AND SWEAT metabolites and enzymes they need to digest their food source, so knowing these three things can greatly affect enclosed growing environments. Most mushrooms also need light to develop. All of these factors will be discussed in the section where appropriate.

Life Cycles

In order to fully understand the cycle we must first focus on the different stages of mushroom development from spores to mushrooms, back to spores again. Mushrooms can produce millions of spores a day, and in nature they are extremely competitive, landing on debris and competing for the space. Cultivators do not use spores since there is already too much competition, and rather use **SPAWN** that is created in a laboratory that has already mated and ready to take over the growing media, or food source, that will outcompete competitor spores and molds. <u>Mushrooms fruit when they run out of space to grow and finish colonizing their food source</u>. There are seven stages of mushroom cultivation as follows for most edible mushrooms:



Media Preparation

There are several ways to prepare the food source, or growing substrate, for the **SPAWN** that will be mixed in, it is up to the grower to experiment with a preferred method. I recommend hot water bath, other methods are listed in my book.

- SHRED TO INCREASE PARTICLE SURFACE AREA TO VOLUME
- HEAT WATER TO 165-180F
- SUBMERGE MEDIA FOR 1-2 HOURS
- REMOVE AND COOL MEDIA
- ADD ADDITIONAL MEDIA WHILE WATER IS HOT, REHEAT IF NECESSARY
- 2 CYCLES MAX FOR WATER REUSE THEN DISPOSE OF WATER WHEN COOL

Inoculation and Container Filling
Once the growing substrate has been prepared to limit competitors, spawn can be introduced. When the media is **COOL TO THE TOUCH AND DRAINED,** sawdust

spawn is the most economical and can be broken up and mixed at a rate of one 5 pound bag per 200lb of wet growing substrate that has been treated. I use two bags of spawn for every bale of shredded wheat straw, for example, that has been soaked in hot water. Once the spawn and the media is mixed it can be transferred into its fruiting containers which ranges from bags, columns, buckets, and bins depending on the fruiting room design. Holes are needed to allow the mushrooms to breathe and escape.

Spawn Run

Once the mycelium from the spawn completely takes over the substrate, water or high humidity will be needed to encourage mushrooms to emerge from the fruiting containers. Hand watering is fine, misters are better if they are intermittent. Mushrooms make heat in this stage, and can overheat, so be careful not to let the internal temperature of your containers stay over 105F for any amount of time. Once the heat drops after colonization, you can move the containers into the warmer environment to fruit, but be careful about incubating containers that are spawn running in a warm space. Most growers have a dedicated room or area with controlled temperatures to maintain 50-70F for this stage to keep the media from going anaerobic and the entire interior killing itself from its own heat.

Complete Colonization

Once the media is colonized it is capable of fruiting, or flushing. The core temperature will drop and cool completely. Water is a key factor and triggers mushroom development. Baby mushrooms are vulnerable and cannot dry out for too long, whereas larger maturing mushrooms do not like a lot of water and can rot, so hand watering has its advantages here where you can select the bags or bins to water. Clear containers make it easier to watch the process at first, but darker opaque containers are best for fruiting. Once the containers have visibly colonized, they can be moved into a fruiting space and watered.

Initiation and Pinning

Once baby mushrooms form, called primordia, they must be watered several times a day and kept in a high humid environment to protect them. Mushrooms need diffused natural light, filtered (85-90% shade cloth), or for interior grow rooms fluorescent or LED lighting works best. Little or lack of light causes the mushrooms to become albinos and are nutritionally inferior, or devoid of vitamin D for example. The fruiting room needs good sir circulation and fresh air introduced to offset the amount of mushrooms fruiting. Too much carbon dioxide can cause the stems to elongate and creates smaller caps, which is undesirable. Once the baby mushrooms start growing they should double in size every day!

Fruiting rooms can be created from greenhouses, old barns, shipping containers, warehouse spaces, just about anything that can be waterproofed for high humidity, provides shade while supplementing lighting if necessary, gas exchange is provided with exhaust fans, and watering and misting is applied at regular intervals.
Typically oyster mushrooms can fruit 3 times the amount as shiitakes per square foot of growing space due to the long colonization time for shiitakes before they fruit (10 weeks).

Fruiting Maturation

Once the fruiting bodies, or mushrooms enlarge they will begin to slow significantly. Picking is all about timing, and you will need to twist off the clusters and store them in produce boxes or bins that breathe in refrigeration until they are cooked or sold. Mushrooms that are left too long release millions of spores and quickly age and can rot when over watered, so reducing watering during this final stage is important for shelf life.

Rest and Recharge

After the mushrooms are picked, the containers can sit and reset with no water stimulation for 2-3 weeks. After a brief drought, the containers can be watered and the holes sprayed to encourage a second, third and fourth flush, and so on…Some strains fruit three times, others as many as ten! Once the fruiting flushes is over, typically 11-15 weeks, its time to discard the growing media and compost it.

Other Topics Covered in this Presentation

- Other species that grow on Agricultural byproducts
- Marketing and Product Development
- Composting
- Scaling Production and Modular systems
- Organic Insect and disease control

CHOOSING WHICH CROPS TO GROW - CROP SWOT ANALYSIS

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What is a SWOT Analysis?
A SWOT Analysis is an examination of your **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats as they pertain to a specific idea or business decision.

Why should I perform a SWOT Analysis?
When beginning or expanding a farm, a SWOT analysis should be performed on the proposed idea because it will assist you in deciding whether or not you should continue pursuing that idea. It can also bring up new ideas or solutions to deficiencies in the operation by examining the situation logically.

What are Strengths and Weaknesses in a SWOT Analysis?
These are features that are <u>internal</u> to your business. In other words, they describe things that are true about yourself or your business operation that exist regardless of outside conditions. Examples of this can be your work experience, education, facilities, existing cash or anything that is an asset or deficiency that is under your control.

What are Opportunities and Threats in a SWOT Analysis?
These are situations that exist <u>external</u> to your business and are out of your control. Things like governmental regulations on your product or the cost of inputs due to an increase in gas prices, for example.

Who should do the Analysis?
Every team member involved in the decision making and planning of the operation should perform one independently. Then, all team members should discuss the results together.

How do I perform a SWOT Analysis?
List items about your business for each SWOT category. Try to be specific enough to identify the core cause or source of each item. List as many points as you can think of for each topic.

How should I use the analysis once I am finished?
1) Use it to capitalize on your strengths and opportunities when creating your strategic plan, mission statement, marketing plan and/or business plan.
2) Prioritize the deficiencies that need to be addressed and develop SMART Goals to resolve them adequately. More information on writing SMART goals can be found in Rutgers Cooperative Extension Factsheet FS1263 http://njaes.rutgers.edu/pubs/fs1263

a. Since the weaknesses are internal (under your control) a plan can be made to improve them.
b. Since the threats are external (not under your control) develop risk management plans to prevent, reduce or eliminate the threat of the risk to minimize its potential impact.

For short videos on farm business management including SWOT analysis go to: https://njaes.rutgers.edu/ultra-niche-crops/business-planning.asp

Farm Viability Programs

Organic Agriculture

OPTIMIZING SOIL HEALTH IN ORGANIC VEGETABLE SYSTEMS

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Soil health is a foundation principle of organic agriculture. A healthy soil optimizes four elements: biology, carbon/soil organic matter (SOM), fertility, and soil structure/physical characteristics. Each of these elements are related and interdependent on one another.

Soil structure is heavily dependent on soil aggregation, which protects soil minerals, organic matter, nutrients, and water. Good aggregation also leads to high porosity, which relates to good water and air movement, root development, and biological activity. Aggregation is affected by soil biology, including arbuscular mycorrhizal fungi (AMF) and soil bacteria. These organisms rely on carbon sources from above and below ground plant growth from diverse sources to thrive. Certain production practices can be detrimental to soil aggregation, including excessive tillage, too little fresh OM going into the soil, bare ground (no mulch or crop on top of the soil), no living cover (thus no roots in the soil) and additions of soluble fertilizers without the concurrent additions of cover crops, mulches, or composts.

Building soil carbon requires a combination of reducing tillage and providing carbon inputs, in the form of cover crops, composts, or manures. Intensive cover cropping, particularly with high biomass cover crops, play a strong role in building soil organic matter. Grass cover crops, with their extensive root systems, are also strong soil organic matter builders. Creative uses of cover crops, such as intercropping alleyways or organic no-till, can be used, but their limitations and risks must be recognized. Resting fields with a multiyear cover crop (such as with a grass that can later be used as a straw mulch, if no seed contamination is present) also is a valuable tool to build SOM.

Optimizing soil fertility in organic systems requires a combination of organic-approved inputs cover crops, composts, and crop rotation. To develop a fertility management plan, you need to know where you are starting from: soil tests are a good way to obtain this baseline. From there, you need to pick a route to reach your goals, looking for landmarks along the way (e.g, yield, quality, and further tissue and soil tests). Proper field sampling is key – land-grant University Extension offices and provide guidance to soil testing.

The role of the soil microbiome is increasingly recognized as a critical component of soil health. The soil food web includes macrofauna (like earthworms) and microfauna (like bacteria and fungi). Soil microorganisms play a key role in soil fertility, by contributing to nitrogen fixation (particularly with leguminous crops and cover crops), enhancing nutrient uptake (e.g., AMF), and mineralizing nutrients from soil organic matter. Enhancing above and below ground plant diversity enhances soil biological diversity, which in turn can add resilience to the system.

Links to soil health resources:

Webinar with attached powerpoint - Cornell Soil Health Assessment: A Diagnostic Approach for Evaluating and Managing Soil Health
http://www.conservationwebinars.net/webinars/cornell-soil-health-assessment-a-diagnostic-approach-for-evaluating-and-managing-soil-health/?searchterm=soil%20health

Iowa State University, Extension and Outreach - Soil health for vegetable crops
https://www.extension.iastate.edu/smallfarms/soil-health-vegetable-crops

USDA - NRCS
Videos - Soil health lessons in a minute
https://www.youtube.com/watch?v=9_ItEhCrLoQ&feature=youtu.be
https://www.youtube.com/watch?v=2JZJB4zM3Y4&feature=youtu.be
https://www.youtube.com/watch?v=81Wxz36SnMc

Fact sheets - Healthy soils are…
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/health/?cid=stelprdb1193043

General list of soil quality indicators and related fact sheets
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=stelprdb1237387

Soil Health Management
https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/mgnt/

Cornell University - Comprehensive assessment of soil health
http://www.css.cornell.edu/extension/soil-health/manual.pdf

OFRF - Building Organic Matter for Healthy Soils: An Overview
http://ofrf.org/sites/ofrf.org/files/Heller_Overview_V7-F-WebRes-150.pdf

SARE - Healthy soils produce healthy crops
https://www.sare.org/Learning-Center/Books/Manage-Insects-on-Your-Farm/Text-Version/Managing-Soils-to-Minimize-Crop-Pests/Healthy-Soils-Produce-Healthy-Crops

BIOPESTICIDES FOR MANAGING DISEASE IN VEGETABLES

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Biopesticides are defined by EPA as pesticides derived from natural materials. There are three types. Biochemical pesticides contain naturally occurring substances that control pests. Substances that control diseases include potassium bicarbonate, hydrogen dioxide, phosphorous acids, plant extracts, and botanical oils. Microbial pesticides contain microorganisms that function as biocontrol agents, affecting the pathogen directly or indirectly through the compounds they produce. Plant-incorporated protectants or PIPs are the least common type of biopesticide. These are pesticidal substances produced by plants that contain genetic material added to the plant often through genetic engineering. The genetic material and the protein it encodes, but not the plant itself, are regulated by EPA. Examples are virus-resistant varieties producing the virus coat protein, which covers virus particles after infection preventing their replication. More information about biopesticides plus lists of active ingredients and products are on the web at http://www.epa.gov/oppbppd1/biopesticides/index.htm. There are also biopesticides for managing weeds and insect pests.

Biopesticides have advantages. Their activity often is targeted to pests and closely related organisms, albeit not always, and they are usually inherently less toxic than conventional pesticides, thus they do not have the same potential to affect birds, beneficial insects, and mammals (there are exceptions, so check the ‘precautionary statements’ section of the label). And thus they typically have short REI and PHI. They generally decompose fast and sometimes are effective in small quantities, thus exposure is lower and potential pollution problems are avoided. Recognizing that biopesticides tend to pose fewer risks than conventional pesticides, EPA has been encouraging their development and use. EPA generally requires less data to register a biopesticide than a conventional pesticide, but enough data about the composition, toxicity, degradation, and other characteristics of the pesticide to ensure that the product will not have adverse effects on human health or the environment. EPA can conduct the registration process more quickly with biopesticides, often taking less than a year, compared with an average of more than 3 years for conventional pesticides. To facilitate their registration, the Biopesticides and Pollution Prevention Division was established in the Office of Pesticide Programs in 1994. Some biopesticides are defined as minimum risk pesticides through FIFRA Section 25(b) rule because their active and inert ingredients are generally recognized as safe (GRAS). These consequently are exempted from the regulation

requirements of FIFRA and thus can be used on any labeled crops for any target since they do not need to be registered as a pesticide. 'Exempt from EPA registration' is stated on the label of these products.
Only products that are registered as pesticides for commercial use or exempt from registration can legally be used for disease control in commercial production in the USA under FIFRA. It is illegal to apply for disease control household products (e.g. hydrogen peroxide and baking soda), compost tea, biostimulants not registered as pesticides, and also pesticides packaged for homeowner use including those that are also marketed for commercial use because only the later label has worker protection and agricultural use information. The target crop must be specified on the label. In some states (NY) the target disease must also be listed.

Limited data on efficacy of biopesticides can be considered their main disadvantage. Data documenting efficacy is not considered when making decisions about registration of pesticides in the USA. Many biopesticides are produced by small companies lacking the R & D funds to support field trials to obtain efficacy data by experienced university and other independent researchers. To help fill this gap, the IR-4 Biopesticide and Organic Support Program funds grants to obtain efficacy information for biopesticides in development as well as those already registered. These funded projects help the program meet its objective, which is to further the development and registration of biopesticides for use in pest management systems for specialty crops (which include all vegetables) or for minor uses on major crops. Information about this program, plus databases of labels and projects are at: http://ir4.rutgers.edu/biopesticides.html.

Most biopesticides are approved for organic production and most products approved for organic production are biopesticides, thus they have a logical excellent fit for managing diseases in organic crops. However some formulations are not approved, which can be due to inerts. For example, the potassium bicarbonate products EcoMate Armicarb O, Kaligreen and MilStop are approved whereas Armicarb is not. Also, some biopesticidal substances are not allowed under NOP (National Organic Program), for example phosphorous acids and genetically-engineered PIPs. Additionally, there are important organic fungicides that are not biopesticides, including mineral oils, copper, and sulfur. Biopesticides break down in the environment, thus there is no concern about build-up in soil as with copper, which is an element. However, biopesticides generally do not have the breadth of activity, efficacy, or residual activity of copper; thus it is important to obtain information about these factors and to know the target disease(s) when selecting biopesticides.

The earlier in disease development that applications are started, the more effective the product will be. This is not unique to biopesticides. Fungicides cannot eradicate established lesions. Some biopesticides, notably LifeGard, Regalia and Serenade, have induced plant resistance as a mode of action. These need to be applied before infection for this activity to be effective.

Several biopesticides have proven effective for diseases affecting vegetable crops. Powdery mildew is perhaps the easiest foliar disease to manage with biopesticides. It can be controlled with several different biopesticides, including botanical oil (Organocide, Mildew Cure, etc), potassium bicarbonate (Kaligreen, MilStop), and microbials (Actinovate, Serenade, Sonata, etc). I maintain lists of efficacy data from published reports I have read under 'Specific Management Practices and Tools:' at http://blogs.cornell.edu/livegpath/organic/organic-management-of-vegetable-diseases/.

<u>Following is a list of some biopesticides labeled for disease control in vegetable crops</u>. The active ingredient follows product name. For products labeled for managing multiple diseases on many crops, labeled diseases of tomato are included to provide some information about the breadth of activity. Products listed with OMRI (Organic Materials Review Institute) are NOP compliant. Check state registration: each product may not be registered in all states. Also, always check with your certifier before purchasing any product. 'No Ag Label' indicates an agricultural label was not found for the product. The list is routinely up-dated and posted under 'Specific Management Practices and Tools:' at http://blogs.cornell.edu/livegpath/organic/organic-management-of-vegetable-diseases/.

Actinovate AG. 0.0371% *Streptomyces lydicus* strain WYEC 108. Labeled for suppressing several foliar and soil-borne diseases on many crops; diseases and crops listed separately. The biocontrol agent colonizes roots, protecting them from pathogens and making minerals and micronutrients more available to plants, which thus are more vigorous and larger. For best results with applications to foliage, label indicates to use a non-ionic spreader-sticker. OMRI-listed. EPA Reg. No. 73314-1. Monsanto BioAg.

BacStop. 2.0% thyme, 2.0% clove & clove oil, 1.5% cinnamon, 1.0% peppermint & peppermint oil, and 1.0% garlic oil. Broadly labeled primarily for bacterial diseases including bacterial leaf spot, bacterial speck, bacterial canker, and bacterial wilt in tomato. Recommended used with EF400 for these and some other diseases. Exempt from EPA registration. USAgriTech, Inc.

Bio-Tam. 2% *Trichoderma asperellum* strain ICC 012 and 2% *Trichoderma gamsii* strain ICC 080. These beneficial fungi have different modes of action and are active over different temperature ranges (starting at 45°F) and environmental conditions. They are effective for diseases caused by *Phytophthora capsici*, *Rhizoctonia*, *Pythium* and *Verticillium*. General label. OMRI-listed. EPA Reg. No. 80289-9-69592. Isagro USA; distributed by Bayer CropScience (formerly AgraQuest).

Cease. 1.34% *Bacillus subtilis* strain QST 713. Broadly labeled for use on greenhouse vegetables. Labeled for bacterial spot, bacterial speck, early blight, gray mold, late blight, and powdery mildew in tomato. OMRI-listed. EPA Reg. No. 69592-19-68539. BioWorks, Inc.

Companion. 0.03% *Bacillus subtilis* strain GB03. Broadly labeled for foliar and soil-borne diseases, including bacterial spot, buckeye fruit rot, damping-off, early blight, Fusarium wilt, gray mold, late blight, white mold, and root rot and crown rot caused by *Pythium* and *Rhizoctonia* in tomato. EPA Reg. No. 71065-3. Growth Products, Ltd.

Contans WG. 5.3% *Coniothyrium minitans* strain CON/M/91-08. Soil-applied product for *Sclerotinia sclerotiorum* (white mold pathogen). OMRI-listed. EPA Reg. No. 72444-1. SipcamAdvan.

Double Nickel 55 LC and WDG. *Bacillus amyloliquefacinens* strain D747, 98.8% and 25%, respectively. Broadly labeled for foliar and soil-borne diseases, including bacterial spot, bacterial speck, damping off, early blight, gray mold, late blight, powdery mildew, and root rot and crown rot caused by *Pythium, Fusarium, Phytophthora, Verticillium,* and *Rhizoctonia* in tomato. OMRI-listed. EPA Reg No. 70051-107 and 108, respectively. Certis USA, LLC.

EF400. 8.2% clove, 8.1% rosemary, and 6.7% peppermint. Labeled for anthracnose and late blight in tomato. Exempt from EPA registration. USAgriTech, Inc.

Kaligreen. 82% potassium bicarbonate. Labeled only for powdery mildew. OMRI-listed. EPA Reg. No. 11581-2. Arysta LifeScience North America LLC.

KeyPlex 350 OR. 0.063% yeast extract hydrolysate from *Saccharomyces cerevisiae*. Combination of defensive proteins (alpha-keto acids) and secondary and micronutrients. Elicits systemic acquired resistance in plants against fungal and bacterial pathogens. Labeled for general disease control in vegetables with specific mention of bacterial leaf spot in tomato. EPA approval for organic production. EPA Reg. No. 73512-4. KeyPlex.

LifeGard WG. 40% *Bacillus mycoides* isolate J. Biological Plant Activator. Labeled for bacterial spot, bacterial speck, early blight, gray mold, and late blight in tomato. OMRI-listed. EPA Reg No. 70051-119. Certis USA, LLC.

MeloCon WG. 6% *Paecilomyces lilacinus* strain PL251. This soil fungus parasitizes many types of plant parasitic nematodes, including root knot and root lesion, without adverse impact on beneficial nematodes. OMRI-listed. EPA Reg No. 72444-2. Certis USA, LLC.

Mildew Cure (formerly GC-3 Organic fungicide**)**. 30% cottonseed oil, 30% corn oil, 23% garlic extract. Labeled only for powdery mildew. OMRI-listed. Exempt from EPA registration. JH Biotech, Inc.

MilStop. 85% potassium bicarbonate. Broadly labeled including anthracnose, early (Alternaria) blight, gray mold, powdery mildew, and Septoria leaf spot in tomato. OMRI-listed. EPA Reg. No. 70870-1-68539. BioWorks, Inc.

M-Pede. 49% Potassium salts of fatty acids. Labeled for powdery mildew and several insects and mites. OMRI-listed. EPA Reg. No. 10163-324. Gowan Co.

Mycostop. 30% *Streptomyces griseoviridis* strain K61. Mycostop can be incorporated in potting mix, applied as a seed treatment, used as a transplant dip, and applied to soil as a spray, drench, or through drip irrigation. It is labeled for control of seed rot, root and stem rot, and wilt caused by *Fusarium, Alternaria, and Phomopsis* of container-grown vegetables and damping-off and early root rot of vegetables in the field. OMRI listed. EPA Reg No. 64137-5. Verdera Oy.

Organocide. 5% sesame oil. Labeled broadly for several fungal diseases and insects. OMRI-listed. Exempt from EPA registration. No Ag Label. Organic Laboratories, Inc.

OxiDate. 27% hydrogen dioxide. Broadly labeled including anthracnose, bacterial speck, bacterial spot, buckeye fruit rot, early blight, gray mold, late blight, leaf (Cladosporium) mold, powdery mildew, and root rots caused by *Fusarium*, *Pythium*, and *Rhizoctonia* in tomato. OMRI-listed. EPA Reg. No. 70299-2. BioSafe Systems, LLC.

Prestop. 32% *Gliocladium catenulatum* strain J1446. Broadly labeled primarily for application to soil for several seed and soil pathogens, and also to foliage for select crops and before fruiting. New formulation expected in 2016 will permit use on edible plant parts thus also enabling label expansion. OMRI-listed. EPA Reg. No. 64137-11. Verdera Oy. U.S. Distributor: AgBio Inc.

Procidic. 3.5% Citric acid. Labeled for damping-off, foliar diseases caused by fungal and bacterial pathogens, and post-harvest diseases. Previously marketed as Citrex. Procidic was reviewed and determined to be NOP compliant by Washington State Dept of Ag. Exempt from EPA registration. Greenspire Global, Inc.

Promax. 3.5% Thyme oil. Protective and curative soil fungicide and nematicide for control of soil-borne diseases and plant parasitic nematodes on a broad range of crops. OMRI-listed. Exempt from EPA registration. Bio Huma Netics, Inc.

Regalia. 5% Extract of *Reynoutria sachalinensis.* Boosts the plant's natural defense mechanisms against certain fungal and bacterial diseases. Broadly labeled including bacterial spot, bacterial speck, early blight, gray mold, late blight, Phytophthora blight, and powdery mildew in tomato. OMRI-listed. EPA Reg. No. 84059-2. Marrone Bio Innovations, Inc.

RootShield WP and Granules (formerly T-22 HC and PlantShield HC). 1.15% *Trichoderma harzianum* Rifai strain KRL-AG2. Protects plant roots against fungal pathogens such as *Rhizoctonia, Pythium*, and *Fusarium*. The biocontrol fungus accomplishes this by growing on roots and releasing enzymes that dissolve the cell wall of many fungal pathogens, which it consumes. OMRI-listed. EPA Reg. No. 68539-3 and -7 for Granules and WP formulations, respectively. BioWorks, Inc.

RootShield Plus WP. 1.15% *Trichoderma harzianum* Rifai strain T-22 and 0.61% *Trichoderma virens* strain G-41. See previous product. OMRI-listed. EPA Reg. No. 68539-9. BioWorks, Inc.

Serenade ASO. 1.34% *Bacillus subtilis* strain QST 713. Replaced Serenade Soil and Serenade Opti. This bacterium colonizes roots and produces compounds that affect pathogens directly and triggers metabolic pathways to activate the plant's natural defenses and modulate growth. Labeled for foliar application targeting anthracnose, bacterial canker, bacterial speck, bacterial spot, buckeye fruit rot, early blight, gray mold, late blight, and powdery mildew in tomato, and applied to soil for *Fusarium, Phytophthora, Pythium, Rhizoctonia,* Southern blight, and *Verticillium*. OMRI-listed. EPA Reg. No. 264-1152. Bayer CropScience (formerly AgraQuest).

Serifel. 9.9% *Bacillus amyloliquefacinens* strain MBI 600. Broadly labeled for foliar diseases, including anthracnose, bacterial spot and speck (supplemental label), buckeye rot, early blight, gray mold, late blight, and powdery mildew. OMRI-listed. EPA Reg No. 71840-18. BASF Corporation.

SoilGard 12G. 12% *Gliocladium virens* strain GL-21. Generally labeled for damping-off and root rot pathogens in field and greenhouse production. OMRI-listed. EPA Reg. No. 70051-3. Certis USA, LLC.

Sonata. 1.38% *Bacillus pumilus* strain QST 2808. Labeled for early blight, late blight, and powdery mildew in field and greenhouse tomato. OMRI-listed. EPA Reg. No. 264-1153. Bayer CropScience (formerly AgraQuest).

Taegro ECO. 13% *Bacillus subtilis* var. *amyloliquefaciens* strain FZB24. Labeled for diseases caused by the soil-borne pathogens *Rhizoctonia* and *Fusarium* in many crops. OMRI-listed. EPA Reg. No. 70127-5. Syngenta Crop Protection.

Tenet WP. Same as Bio-Tam. OMRI-listed. EPA Reg. No. 80289-9. Isagro USA; distributed by SipcamAdvan.

TerraClean 5. 27% hydrogen dioxide and 5% peroxyacetic acid. Generally labeled for control of soil-borne plant diseases such as those caused by *Fusarium* (root rot), *Phytophthora* (blights, rots), *Pythium*, and *Rhizoctonia* on any crop. It penetrates soil to kill and suppress pathogens, and it releases vast amounts of oxygen that stimulates root development, nutrient uptake, and thus plant growth. OMRI-listed. EPA Reg. No. 70299-13. BioSafe Systems, Inc.

Thyme Guard. 23% thyme oil extract. Broadly labeled for diseases like Botrytis gray mold, late blight, powdery mildew and others caused by fungi, bacteria, viruses, and nematodes. Exempt from EPA registration. Determined to be NOP compliant by Washington State Dept of Ag. Agro Research International.

Timorex Gold. 23.8% tea tree oil. Labeled generally for several diseases, including anthracnose, bacterial diseases, early blight, gray mold, late blight, and powdery mildew in tomatoes. OMRI-listed. EPA Reg. No. 70051-2. Stockton USA, LLC.

Trilogy. 70% clarified hydrophobic extract of neem oil. Labeled generally for several insects and diseases. Labeled diseases that occur in tomato include anthracnose, early blight, Botrytis (gray mold), and powdery mildew. OMRI-listed. EPA Reg. No. 70051-2. Certis USA, LLC.

Zonix biofungicide. 8.5% Rhamnolipid Biosurfactant. Kills zoospores, which is one spore type produced by Oomycete pathogens which cause diseases such as late blight. OMRI-listed. EPA Reg. No. 72431-1. PropTera, LLC.

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. If you are farming organically, before purchase make sure product is registered in your state and approved by your certifier. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

GROW AND PROCESS VALUE-ADDED GRAINS

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The benefits of including small grains in the rotation are well known. These crops quickly establish a dense ground cover that protects against soil erosion, produce large amounts of biomass (straw) that contribute organic matter to the soil, have fibrous root systems that effectively scavenge soil nutrients, and can be readily intercropped with nitrogen-fixing forage legumes. In addition, as grasses small grains can help break disease cycles in broadleaved crops.

Because of these benefits, vegetable growers are strongly encouraged to grow small grains as cover crops within their systems. However, a major drawback to growing cover crops is that they take land out of cash crop production. With the burgeoning local foods movement—which includes strong demand for locally grown grains—there is now an opportunity for vegetable farmers to reap both ecosystem benefits and profit in growing these crops.

Locally grown, organic grains fetch high prices. A modern variety of wheat, for example, can be sold for \$0.30/lb (\$18/bu) or higher to the organic mills that are proliferating in our region—or for \$1.00/lb or more when sold at farmers' markets. Specialty small grains command even higher prices. The so-called ancient wheats, spelt, emmer, and einkorn, for example, are prized by consumers for their distinctive tastes and nutritional benefits. When grown organically and sold directly to consumers or chefs, cleaned berries (kernels) of these crops range in price from \$1.50 to \$6.00 per pound. Processing also adds more value to locally grown grains. Diverse processing options exist, from milling flour to producing finished foodstuffs (such as rolled oats, artisan bread, and pasta) or fermented or distilled beverages.

To achieve the high profit potential of these crops as locally grown grains, attention to grain quality is critical. While farmers and researchers have shown that a wide variety of small grains can successfully be grown as food-grade crops in our region, the humid growing conditions in the Northeast increase the risk of disease. The most serious disease is *Fusarium graminearum (head blight), which infects wheat, barley, and rye (oat is a weak host) and can produce deoxynivalenol or DON (also known as vomitoxin) in the crop at levels which render the grain inedible. Farmers need to monitor for symptoms of the disease during the growing season and to test harvested grain for presence and level of DON contamination. Because crop rotation is a major preventative strategy for F. graminearum, vegetable growers who can alternate small grains with broad-leaved crops are well placed to reduce the risk of the disease.*

Other grain quality parameters vary depending on the use to which the grain is put. For example, for bread wheat flour, a grain protein content of 12% or higher is desirable as is minimal sprouting of the grain in the head (measured as falling number). Protein and falling number are affected by variety selection and growing conditions, but management practices, such as timely planting and harvesting of the crop, are also critical.

As with vegetable crops, proper post-harvest handling procedures are needed with grains to maintain product quality. Harvested grain must be immediately cleaned of any green material (e.g., weed seeds or stem/leaf material) to prevent molding or transfer of odors to the grain. Grain must be checked for moisture and dried if necessary to achieve 13% moisture content for safe storage. Stored grain must also be protected against insect pests (e.g., Indian meal moth and grain weevils) through monitoring and sanitation procedures and temperature control.

To successfully produce high-quality grain for local food markets, certain specialized equipment is needed. Grain may be broadcast using spin seeders, but a grain drill helps to ensure adequate crop stand and yield. A combine is essential for timely, efficient harvesting. Access to a grain cleaner or cleaners, drying mechanisms, and storage bins or a climate-controlled storage area is also necessary. Additional equipment will be needed for those interested in adding value through grain processing.

For vegetable growers, the list of needed equipment can be daunting. New equipment is expensive and often not suited for smaller-scale production. Fortunately, there are solutions to this equipment conundrum. One option is to purchase used equipment: Used grain drills, small combines, and air-screen and other grain cleaners are affordably priced and generally available in the region. For harder-to-source equipment, other options are being developed. For example, dehulling capacity is needed to successfully produce and market the ancient wheats, whose kernels do not readily separate from the hull in the combine. Commercial dehullers are available in the U.S. but can cost from $10,000 to $20,000 new or over $5,000 as used equipment. Farmers have overcome this hurdle by modifying existing equipment (e.g., replacing one or both of the metal plates in a used feed mill with rubber disks at a cost of $300-$400) or building their own machines. A farm-manufactured dehuller is now for sale for $1500 and other low-cost models of dehullers and other processing equipment are being developed and tested.

A new project*, Farmer-generated training and equipment solutions for producing and processing value-added grains*, funded by NE SARE, will provide an intensive training program to help farmers 1) develop expertise in best management practices for food-grade grain production and 2) access and efficiently use affordable, scale-appropriate production and processing equipment. OGRIN, in collaboration with NOFA-NJ, will hold multiple training events in New Jersey, Pennsylvania, and New York over the next two years. More information on the project can be found at the OGRIN website (www.ogrin.org).

NON-CHEMICAL WEED CONTROL FOR ORGANIC SYSTEMS

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Weed management in organic crop production systems cannot rely on synthetic herbicides, even as a last resort or "rescue" operation. Therefore, preventative measures such as field sanitation, cultural practices such as crop rotation, and non-chemical methods of direct weed control such as tillage and cover crops are fundamental aspects of organic crop production. Most importantly, weed management in organic crop production systems requires a long-term approach to avoiding weed problems. Careful monitoring and long-term planning are the keys to successful weed management in organic systems. This presentation will cover the basics of a successful weed management program from proper weed identification to the selection of appropriate tools to control weeds.

Understanding Weed Biology

A good understanding of weed biology is a prerequisite in developing a preventive approach of weed management. Proper identification and knowledge of the reproductive and spread characteristics of various weed species will help to choose the most appropriate weed management strategy. For example, cultivating a creeping perennial weeds such as quackgrass or Canada thistle in the spring may divide underground vegetative structures into smaller fragments from which new plants can sprout. In that case, cultivation would help to spread tough-to-control weeds and worsen weed control.
Weeds can be divided into three groups. Grasses are a single botanical plant family with jointed stems, leaves with parallel veins that are divided into a blade and a sheath that wraps around the stem. Sedges appear like grasses at a glance. Leaves are narrow with parallel veins, but they are not divided into a blade and sheath. Sedges have a distinctly triangular stem. Broadleaf weeds are a large collection of diverse plant families that have wide leaves, showy flowers, and seeds that are divided into two halves. Among these three groups, species can be subdivided based on their seasonality. Annuals are weeds that live less than a year. Summer annuals germinate in the late spring and early summer, flower and set seed in late summer or early fall and die when it gets cool. Winter annuals germinate in the fall or early spring, flower and set seed in late spring, and die when it gets hot. Biennials are weeds that live longer than a year, but less than 2 full years. Perennials are weeds that live longer than 2 years.

Weed Identification

Accurate weed ID is important for effective control because mechanical, cultural, and biological weed management strategies vary according to weed species. Some species can look similar to 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 (http://www.cornellpress.cornell.edu/book/) or weed identification websites (http://oak.ppws.vt.edu/~flessner/weedguide/) can be helpful to accurately determine weed species and become familiar with their biology and ecology.

Prevention

The first step of any weed management program is to consider the steps that need to be taken to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species. This includes the purchase of weed-free seeds when seeding the crop or sodding the row middles, the necessity of cleaning equipment before moving from infested to non-infested fields, or the use of weed-free irrigation water. Most importantly, preventive weed management strategies should always target prohibiting weeds already present from producing seeds and replenishing the soil seedbank. Weed seeds can live for many years, depending on the species and whether the seed is exposed or buried beneath the soil surface. Thus, the destruction of weeds on field borders and ditches as well as within the crop before seed ripening is a key element of an effective weed prevention program.

Weed Scouting

Prevention is a necessary step but is not sufficient by itself. Weeds have generally to be targeted at the seedling stage since controlling fully developed weeds can be extremely difficult because of their ability to regrow following mechanical 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). 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. This is especially important as weed management in organic crop production systems requires long-term planning and consistency in the implementation of weed control techniques.

Biological Weed Control

Biological weed control is the deliberate use of natural enemies to reduce the density of a specific weed to a tolerable level. This includes various weed control tools such as insects, mites, nematodes, pathogens, and grazing animals. In specialty crops relative to biological weed control, managing a cropping system to increase the populations of natural weed seed predating organisms has the greatest potential to help reduce weed populations. Rodents, ants, crickets and ground beetles can consume a tremendous number of weed seeds and contribute to reducing the replenishment of the soil weed seedbank. Cultural practices that will promote the development of a favorable environment to these predators will help increasing weed seed predation. This includes reducing use of insecticides that often kill not only target insects but also beneficial insects, encouraging conservation tillage and no-till practices to decrease destruction of habitats that are favorable to weed seed predators, delaying tillage to keep weed seed on the soil surface and increase seed predation, incorporating cover crops into the cropping system to create habitat for weed seed predators, and promoting the development of insecticide-free refuge areas where weed seed predators can reproduce and overwinter.

Cultural Weed Control

Agronomic practices that make conditions more favorable for crop and less favorable for weeds are considered as cultural control strategies and are key components of weed management in organic cropping systems. This usually includes crop rotation, planting date, stale seedbed, soil fertility, variety selection, seeding rate, and row spacing. All these techniques can be combined to maximize their efficiency at controlling weeds.

Rotating crops that have different growth habits, growing seasons, and plant architecture characteristics will disrupt weed life cycles. Planting a more competitive crop that will suppress certain weeds can help managing weeds in a subsequent less competitive crop. For example, including a hay crop in the rotation will help managing some broadleaf weed species (pigweed, lambsquarters…) because they are not as competitive in a densely planted grass crop than in a broadleaf crop and mowing of hay field can reduce weed seed production. Proper selection of the planting date can give a competitive advantage to the crop by allowing it to quickly develop a dense canopy that can efficiently intercept sunlight and maximize ground cover. Delaying the planting of spring-seeded crops when soil temperature is higher will favor rapid crop emergence, reduce the duration of the critical weed-free period following emergence, and stimulate the formation of a dense canopy. This tool can be combined with techniques that stimulate weed germination and subsequent destruction before crop planting (stale seedbed) to optimize weed control. Stale seedbed involves the preparation of a seedbed that is tilled several weeks before crop planting. This will stimulate the emergence of weeds that can then be killed, while still small, by shallow cultivation, flame weeding, or other nonselective methods. Depending on the length of time before planting, one or more flushes of weeds may emerge and be killed between seedbed preparation and planting. The success of a stale seedbed depends on the weed spectrum and the time of planting. Finally, various tactics that increase crop competitiveness by allowing crop to reach rapid canopy closure will help reduce the impact of weeds. Proper selection of crop varieties adapted to local soil and climate conditions that quickly establish a canopy, retain it longer, and have some tolerance to pests and diseases is critical for weed management. Weed control will also benefit from increased seeding rates and use of narrow row spacing as these strategies will allow the crop to reach canopy closure faster.

Mechanical Weed Control

Mechanical weed control is critical for managing weeds in organic systems and includes the use of preplant and postplant tillage.

Preplant tillage using plowing, disking, and field cultivating can help reduce the density and spread of certain non-rhizomatic perennial weeds, kill emerged weed seedlings and bury weed seeds below the germination zone.

Postplant cultivation between crop rows should generally begin a few days after planting to control recently emerged small weed seedlings using rotary hoe, spring-tine harrow, or tine weeder. Cultivation works best when performed during the heat of the day in bright sunlight; weeds quickly desiccate and die under these conditions. Rainfall shortly after cultivation or wet cloddy soils at or following cultivation may allow weeds to recover and survive. Hand-pulling escaped weeds will help ensure maximum crop yield and prevent weed seed production, which can affect future weed problems.

Cover Crops

In the Northeast, common cover crop species include cereal rye and hairy vetch, which are typically established in the fall following corn or soybean harvest or in the early spring prior to planting summer vegetables. While actively growing, cover crops can provide some weed control by directly competing with weeds for light, space, water, and nutrients. Cover crops may contain allelopathic chemicals, which are exuded from living or decaying plant tissues. These compounds may prevent weed seed germination or negatively interfere with weed growth. The effect of cover crop will vary depending on weed species and time of cover crop establishment. Usually, perennial weeds will be less affected by cover crops than annual weeds.

When cover crops are terminated, their residues (mulch) left at the soil surface can also suppress weeds by blocking light from reaching the ground, thus preventing the germination of some weed seeds. Similarly, the shading of the soil surface by cover crop mulch with slow the growth of already emerged weed seedlings and make them less competitive with the crop. By lowering soil temperature, cover crop mulch can contribute to delay the seed germination of weed species that require soil warming to germinate.
Optimization of cover crop benefits for weed control require to maximize cover crop biomass through the establishment of a dense cover crop stand and the longest possible duration of living cover crop in the field.

Blueberries

IR-4 LABEL LIMITATIONS AND EXPECTATIONS

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The IR-4 Project has been the main facilitator for the US government registration of crop protection products, including pesticides, biopesticides and other technology for blueberries and other specialty crops. IR-4 operates as a unique partnership between the U.S. Department of Agriculture, (including the National Institute of Food and Agriculture, Agriculture Research Service, Foreign Agriculture Service and Animal and Plant Health Inspection Service); Rutgers/NJAES and the other State Agricultural Experiment Stations, the U.S. Environmental Protection Agency, the crop protection industry, commodity associations and growers/farmers. Over the past 55 years, IR-4 has facilitated nearly 19,000 pesticide/biopesticide registrations on specialty food crops or minor uses on major crops.

IR-4 ability to support new registrations of crop protection tools has become increasing complex and costly due to a variety of factors. There is concern that IR-4 ability to service the needs of the specialty crop community is decreasing while the need for IR-4 continues to rapidly increase. Some of the challenges/threats for approval of new crop protection registrations for specialty crops include:

- Product Performance Data Requirements – The crop protection industry has traditionally funded or developed within its internal infrastructure crop safety and product performance data for many specialty crops. This includes data showing performance with commercial formulations in tank mixes with other products or with different adjuvants. Because of financial challenges within companies, there is a huge gap in the required product performance data. Additionally there are significantly less applied scientists at the universities who are capable of conducting these studies. More importantly, the amount of this product performance data has increased as the companies proactively try to protect their products from crop damage liability issues.

  IR-4 has established a Product Performance Team to provide apocopate focus to this issue. IR-4 has also increased its fiscal investment in product performance data development. **However the required resources to develop necessary data is significantly lacking**. This has led to potential product registrations not being available to farmers/growers or certain uses never approved.

- Pesticide registrations are managed by the court system – For a variety of reasons the state and federal court systems become actively involved in the regulation of pesticides. Much of the courts activities are being triggered by lawsuits from Non-Government Organizations who sue EPA to make changes to the provisions of registrations. In some cases, these lawsuits are asking for wholesale cancellation of certain chemical classes of pesticides (e.g. neonicitoids). It other cases, EPA is sued demanding that product registrations be vacated because EPA did not follow certain provisions of its registration process. The courts also get involved in crop damage liability issues. The bottom line, the court involvement takes away the ability of scientists to review data and make logical opinions based on sound science. Court involvement in the registration of crop protection products limits the availability of products to farmers/growers.

- Mergers in industry – Over the past 18 months there has been several major mergers in the crop protection industry. These mergers typically take time to allow successful integration of assists and resources. During the transition time, there is often paralysis by analysis; decisions are delayed or not made. We are also concerned that the mega-mergers will lead to the new companies having a higher economic threshold for their support of new specialty crop uses as well as less investment by industry in new technology.

- US Government funding – IR-4 funding from federal sources has remained flat for the past nine years while expenses continue to rise. IR-4 has had to reduce its research plan in all program areas to balance available resources. This has led to closure of some of IR-4 research sites. Future funding with existing federal investment in agriculture research looks increasing bleak. In fact, the President Fiscal Year budget proposal call for elimination of 10 USDA-Agricultural Research Service projects that develop IR-4 data. If approved, this would reduce IR-4 research capacity by over 20%.

- University service fees - IR-4's current federal authorizing language does not allow universities that receive IR-4 funds to charge indirect costs or overhead. Many of the units currently hosting IR-4 are under intense fiscal challenges and they can no longer absorb these indirect costs. A few years back, Cornell University ended IR-4 involvement because of such costs. Others, including Rutgers may be forced to follow Cornell's approach. USDA believes they can modify IR-4 authorizing language to allow host institution to collect 10% overhead. IR-4 is concerned that without new funds to replace the $1.2 million transferred to the host institutions, it would be devastating to IR-4; in other words a loss of this magnitude could not be absorbed.

Dan Rossi has rejoined IR-4 and is working with the Executive Director and other members of management on a "Path Forward" plan to tackle many of these issues while allowing IR-4 to remain the go-to organization for the registration of crop protection products for specialty crops. Some ideas suggested include:

- Solicit new funding partners from the produce supply chain
- Embrace contract research
- New grants from public and philanthropic sources
- Coordinated effort by specialty crop community to have Congress upwardly adjust IR-4 funding

What can you do? We request that you become an active participant in ongoing efforts by numerous commodity associations/food processors and other organizations to educate and advocate for increased funding for IR-4 from the US Congress; **the current request is to increase IR-4 funding from $11.9 million to $19 million.** IR-4 also encourages the private sector to establish or increase an annual unrestricted contribution to IR-4. Finally please educate others in your networks about the contributions of IR-4 to crop protection and food production; let them know of the critical fiscal challenges IR-4 is facing; please help us make connections with others who can help.

PROGRESS TOWARDS SPOTTED WING DROSOPHILA MANAGEMENT IN BLUEBERRIES

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Spotted wing drosophila (SWD), *Drosophila suzukii*, emerged since 2008 as a severe insect pest of small fruits in North America. These flies are native to Southeast Asia and infest several crops including blueberry, raspberry, blackberry, cherry, and strawberry. Adult flies are 2 mm in length and male flies can be identified by black spots on the tip of their wings. Female flies have a large, sword-like ovipositor on the tip of their abdomens that they use to pierce the soft flesh of ripening fruit. Unlike other non-SWD *Drosophila* flies that lay eggs primarily on decaying and rotten fruit, SWD attacks only blushing and ripening fruit. Once a female has pierced through the flesh to lay her egg it hatches and the developing larvae proceeds to feed on the inside of the fruit. The wounds caused by females' sword-like ovipositors also leave the fruit susceptible to secondary microbial infection. Recent reports suggest that North American small fruit growers could face upwards of 30 million dollars in crop loss due to SWD damage.

Presently the only viable tool to control SWD populations is frequent applications of chemical insecticides. These insecticides are not always effective against the developing larvae as they are protected inside the fruit. Growers cannot time insecticide sprays with adult movement because the commercially available traps rely on non-specific volatile blends that attract large numbers of non-target insects. Because of the labor required to sort the SWD from non-SWD *Drosophila* flies in these traps, growers typically apply insecticides on a calendar basis hoping to knock-down host-seeking adult flies. This need has led to extensive research on the visual and chemical cues that guide SWD flies in finding their small fruit hosts.

Work in both the laboratory and field has shown that flies are more attracted to the color red versus other colors. Flies are also attracted to spherical objects and as the size of the sphere increases so does fly attraction. This work may lead to the use of red, spherical, insecticide baited traps (Fig. 1) that could be used for monitoring and management (i.e., attract-and-kill) purposes.

Available commercial lures rely on a mixture of volatile components from fermentation odors. However, as mentioned above, these odors also attract non-SWD *Drosophila* flies. A large multi-state project is currently deploying traps baited with different formulations to improve the specificity of fermentation, yeast, and leaf odors for SWD. This project has deployed traps in New Jersey, New York, North Carolina, Michigan, and Oregon in several crops including blueberry, raspberry, blackberry, and cherry. Preliminary results suggest that the addition of conflicting odors (for example fermentation odors plus yeast odors or fermentation odors plus leaf odors) may actually repel host-seeking SWD flies.

We are currently investigating various mixtures of these odors in the lab to better understand this interaction. Preliminary work has also suggested that the combination of red spheres baited with volatile odors may boost SWD attraction versus either red spheres or volatile odors alone. We are confident that this work will lead to a more specific and economically viable trap for small fruit growers in North America to monitor SWD populations.

Fig. 1. Red attracticidal sphere

MICROBIAL COMMUNITIES IN BLUEBERRY SOILS

James Polashock[1], Joseph Kawash[1] and Peter Oudemans[2]
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Microbial communities thrive in the soil of the plant root zone and these communities play a critical role in plant productivity. Microbes can directly affect plant health positively (such as mycorrhizae-which are beneficial symbionts) or negatively (such as plant pathogens), while others are neutral or contribute indirectly. These communities are very complex and consist of billions of organisms from different taxonomic groups (e.g. bacteria, fungi, arthropods, nematodes).

Although blueberry fields can be productive for decades, yields sometimes decline over time and fields that are replanted often underperform and/or take too long to establish. We contend that declining soil health contributes to reduced yields in older fields and poor establishment of replanted fields.

Traditionally, measurements of soil health are limited to analysis of nutrients and physical characteristics. Yet, the soils are 'alive' and understanding the community of living organisms in the soil can be just as important as nutrient analysis. To identify the inhabitants of the soils in the root zone of blueberry plants, we collected soil samples from 30 commercial farms in Burlington and Atlantic counties. DNA was isolated from the soil with the expectation that DNA of all of the organisms in a given sample are represented in the extract. Barcode regions of the DNA were then selectively amplified. The barcode is a small fragment of DNA that can be used to identify the organism from which it was extracted. Specifically, we amplified a portion of the 16S ribosomal DNA to identify bacteria, the ribosomal intergenic spacer (ITS) region to identify fungi, and the 18S ribosomal DNA to identify nematodes. The sequence data were then compared to extensive databases where similarity was used to classify the organisms from which they were derived. Results from all samples were used to identify the 'core' microbial community associated with commercial blueberry culture and represents the first time such analyses were conducted.

The bacterial communities were remarkably similar across all soils samples, sharing 15 (30%) of the identified phyla. While the fungal communities were more diverse; only 5 (20%) phyla were present in all samples. Nematodes that have not yet been reported to occur in these soils were tentatively identified. We found evidence of over 50 different genera, including potential plant pathogens. This finding needs to be verified by more direct methods such as 'washing' the nematodes out the soil samples and identifying them based on morphological features.

Once the 'core' is established, it will be easier to determine how deviations from the core assemblage of organisms affect plant health. Assays to rapidly detect those found to impact plant health will be developed.

Food Safety Modernization Act Training

FOOD SAFETY MODERNIZATION ACT PRODUCE SAFETY RULE TRAINING

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Who Should Attend

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 attend this 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!

What to Expect at the PSA Grower Training Course

This is approximately 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)
- 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 should come prepared 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 on the farm
- 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 and submit the appropriate paperwork to the trainers at the end of the course.

Cost to Attend:

The cost to attend the grower training course will vary depending whether it is a one or two-day course. The one-day session will cover the requirement for FSMA training. The second day will be for those who want to develop a written food safety plan which is not required for FSMA, but is required if going through an audit. The one-day course is $50.00/person and the second day (optional) is $25.00/person. The training at the Agricultural Convention is $35.00 for one day since lunch is not included. These trainings are being partly funded through grants from the New Jersey Department of Agriculture and the Food and Drug Administration. For those who cannot attend the training in Atlantic City the following courses are being offered across New Jersey.

February 20 and 21, **FSMA- Produce Rule Training and Third-Party Audits,** Rutgers Cooperative Extension of Mercer County, 930 Spruce Street, Trenton, NJ 08648. $50.00 for day 1 or $75.00 for both days, 9am-4pm. Lunch included both days.

February 28 and March 1, **FSMA- Produce Rule Training and Third-Party Audits,** Rutgers Cooperative Extension of Cumberland County, 291 Morton Avenue, Millville, NJ 08332. $50.00 for day 1 or $75.00 for both days, 9am- 4pm. Lunch included both days.

March 14, **FSMA- Produce Rule Training for Blueberry Growers,** Philip E. Marucci Center for Blueberry and Cranberry Research, 125a Lake Oswego, Chatsworth, NJ 08019. $50.00 per person, 9am-4pm. Lunch included.

To register or for more information please visit:

https://rutgersonfarmfoodsafety.eventbrite.com

If you are unable to register on line call Tammy Commander at (856) 451-2800, ext. 1 or email: commander@njaes.rutgers.edu

Fumigation Workshop

FUMIGATION WORKSHOP

Rick VanVranken[1] and David Bachinsky[2]
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[2]Crop Production Services
471 Landis Avenue, Bridgeton, NJ 08302

8:00 - Introduction to Workshop & Presenters - the EPA Soil Fumigant Training & Certification Program

-- **Mike Herrington**, High Value Crop Specialist, Amvac Chemical
-- **Ben Soistman**, NE Territory Representative, Amvac Chemical

8:30 - Overview & Introduction to Fumigating
Chemistry of Metam Fumigants
Handling & Logistics
Application Equipment
PPE & GAP's
Research Data & Pests Controlled

9:15 – BREAK

EPA Soil Fumigant Training & Certification Program

9:30 - Module 1 - Soil Fumigants & How The Work; Hazards, First Aid & Safety; Understanding the Role of Applicator & Handler

10:00 – Testing of Module 1 Test

10:30 - Module 2 - How to Protect Handlers & Bystanders; Emergency Response Plans & Emergency Preparedness & Response Measures

11:15 – Testing of Module 2 Test

12 noon LUNCH BREAK

12:45 - Module 3 - The Fumigation Management Plan; How to Recognize Unfavorable Application Conditions

1:30 – Testing of Module 3 Test

2:00 - Module 4 - Buffer Zones & How to Determine Buffer Zone Distances;
Application Rates & How to Determine Broadcast Equivalent Rates

2:45 – Testing of Module 4 Test

3:15 – Break

3:30 - Module 8 - Metam Fumigants

4:15 – Testing of Module 8 Test

5:00 - Retesting for those who did not pass or Class Ends with Questions,

Re-certification credits Requested

Sprayer Technology Workshop

SPRAYER TECHNOLOGY WORKSHOP FEBRUARY 8, 2018

John Grande, Geoffrey Slifer and Curtis McKittrick
Rutgers University Snyder Research and Extension Farm

The use of backpack sprayers for small-scale horticultural crop production as well as basic calibration steps are presented to session participants. A series of instructional videos can be accessed at the link below as a resource to participants. Companion handout materials are included below which correspond to the videos available on the Rutgers University Snyder Farm website.
http://snyderfarm.rutgers.edu/snyder-backpack-sprayers.html

1-selection criteria for backpack sprayers to maximize performance and ease-of-use. Significant differences in performance and ease-of-use exist between various models of backpack sprayers. For instance recent advances 2016 – 2017 in lithium-ion battery performance including lower pricing now allow battery operated backpack sprayers to be considered for use in small-scale vegetable production. Backpack sprayers will be demonstrated during the workshop.

2-calibration will be discussed during the workshop as it relates to both backpack sprayers and tractor mounted sprayers. The importance of calibration will be emphasized including significant economic advantage to accurate calibration to the farmer as well as regulatory compliance and pesticide label compliance.

3 – nozzle design and spray droplet patterns as they impact pesticide performance based upon the type of pesticide utilized. Additionally, drift control will be discussed from a regulatory, pesticide performance and personal protection criteria..

4 – an overview of air assisted sprayers specifically as it relates to calibration will be discussed.

NOTES