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New England Vegetable and Fruit Conference

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Manchester, NH

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New England Vegetable & Fruit Conference and Trade Show

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DoubleTree by Hilton Downtown
Manchester, NH

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Sweet Corn Herbicides: Modes of Action and Use Considerations

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Weeds are a threat to annual specialty crops because they compete for water, nutrients, and light. Dense populations also interfere with harvestability and can reduce the quality of achieved yields. Weeds that are unmanaged can set seed, which are returned to the soil seedbank (and which becomes problems in following years). To manage unwanted vegetation, growers heavily rely of herbicides.

Herbicides can be defined in many ways including:

- When/where they are applied – e.g. preemergence (before weeds emerge) vs postemergence (after weeds emerge), soil-applied vs foliar-applied.

- How they move in the plant – e.g. contact (damages only the tissue it is applied to) vs systemic/translocated (is moved in the plant from the treated site to its target site, where it is active).

- By their spectrums of control – e.g. broad (controls many species) vs selective (controls few species, certain plant families, certain plant classes).

- By their modes of action (MOA)

What is an MOA? The MOA is the way in which the herbicide controls susceptible plants. It describes the biochemical or physiological process that the herbicide interrupts, resulting in plant injury and/or death. Knowledge about a herbicide's mode of action is important for selecting and appropriate herbicide given known weed control targets, diagnosing crop injury resulting from herbicide applications, planning for safe crop rotations, and developing a weed management program that can mitigate or prevent the development and spread of herbicide resistance. Current herbicide MOA classifications can be found at the Herbicide Resistance Action Committee website: https://www.hracglobal.com/who-we-are/about#:~:text=The%20global%20Herbicide%20Resistance%20Action%20Committee%20%28HRAC%29%20is,supporting%20efforts%20in%20the%20fight%20against%20herbicide-resistant%20weeds.

In sweet corn, there are several modes of action available. Primary products belong to Weed Science Society of America (WSSA) groups 2, 3, 4, 5, 6, 15, 22 and 27. Herbicides in groups 5 and 6 (photosystem II (PS II) inhibitors), group 22 (Photosystem I (PS I) electron diverters), and group 27 (hydroxyphenyl pyruvate dioxygenase (HPPD) inhibitors) result in "burning" of plant tissues through the generation of reactive oxygen species. Groups 5, 6 and 22 interfere with the normal activities of photosynthesis while group 27 affects the synthesis of carotenoids, which protect chlorophyll molecules from light-mediated damage. Examples of active ingredients

include atrazine (WSSA 5), bentazon (WSSA 6), paraquat (WSSA 22), and mesotrione (WSSA 27). Herbicides in WSSA group 2 (acetolactate synthase (ALS) inhibitors and WSSA group 15 (very long chain fatty acid (VLCFA) inhibitors disrupt cellular metabolism in treated plants. Specifically, the ALS inhibitors disrupt the synthesis of long chain amino acids, which are used in the formation of plant proteins. VLCFAs are important in the development of wax, suberin, and cutin, which make up the leaf cuticle, as components of the endodermis, and as anchors for cell membrane proteins. Examples of WSSA groups 2 and 15 include nicosulfuron and S-metolachlor, respectively. WSSA groups 3 and 4 herbicides interfere with cell division and growth. Group 3 products (dinitroaniline or "yellow" herbiicides, like pendimethalin) inhibit microtubule assembly; microtubles make up spindle fibers which are needed for cell division. Synthetic auxins (like 2,4-D), which are WSSA 4, disrupt many cellular processes and can affect cell wall plasticity and nucleic acid metabolism.

The following are some general notes about preemergence herbicide use:

- Preemergence herbicide incorporation and efficacy can be affected by the presence of debris and a clean spray surface improves control potential for many products.
- Perennial weeds are not likely to be impacted by preemergence herbicides.
- Tank mixes may be necessary to increase the spectrum of weed control; some products may have some postemergence activity but should not be relied on to control standing vegetation.
- Preemergence herbicides can injure crops, not just from root damage but also from contact with foliage or stem tissue.
- Pay attention to incorporation/activation requirements.
- Herbicide use rates can be dependent on weed species present, soil type, soil organic matter content, and crop growth stage.
- Herbicides can have limits on the numbers of sprays, the separation of sprays (sequential application timings), or the amounts of product applied per year.
- The longevity of preemergence herbicide efficacy can be affected by use rate, herbicide chemistry, soil type, organic matter, soil microbial community composition and activity, and environmental factors that facilitate breakdown.
- Herbicide resistance can develop for residual products. Rotate herbicide modes of action as is possible and use alternate control strategies when appropriate for weed suppression.

The following are some general notes about postemergence herbicide use:

- Not all herbicides/herbicide formulations are equally safe on all varieties.
- Weeds are best controlled when small, < 2" to 3" in size; stressed plants may be less sensitive to treatments (e.g. especially a concern with systemic herbicides).
- Even when systemic herbicides are applied, perennial weeds will require multiple treatments for suppression.
- Postemergence herbicides may require spray tank additives (such as surfactants) to maximize control efficacy. Water quality and pH can also affect performance.
- Optimal spray volumes (more is not always better) and appropriate nozzle selection can vary among herbicides.
- Direct contact with plant tissue can result in crop injury.

- Rotate herbicide modes of action as is possible and use alternate control strategies when appropriate for weed suppression.

Always follow the labels to maximize weed control and crop safety, reduce off-target movement, and minimize the potential for unnecessary exposure.

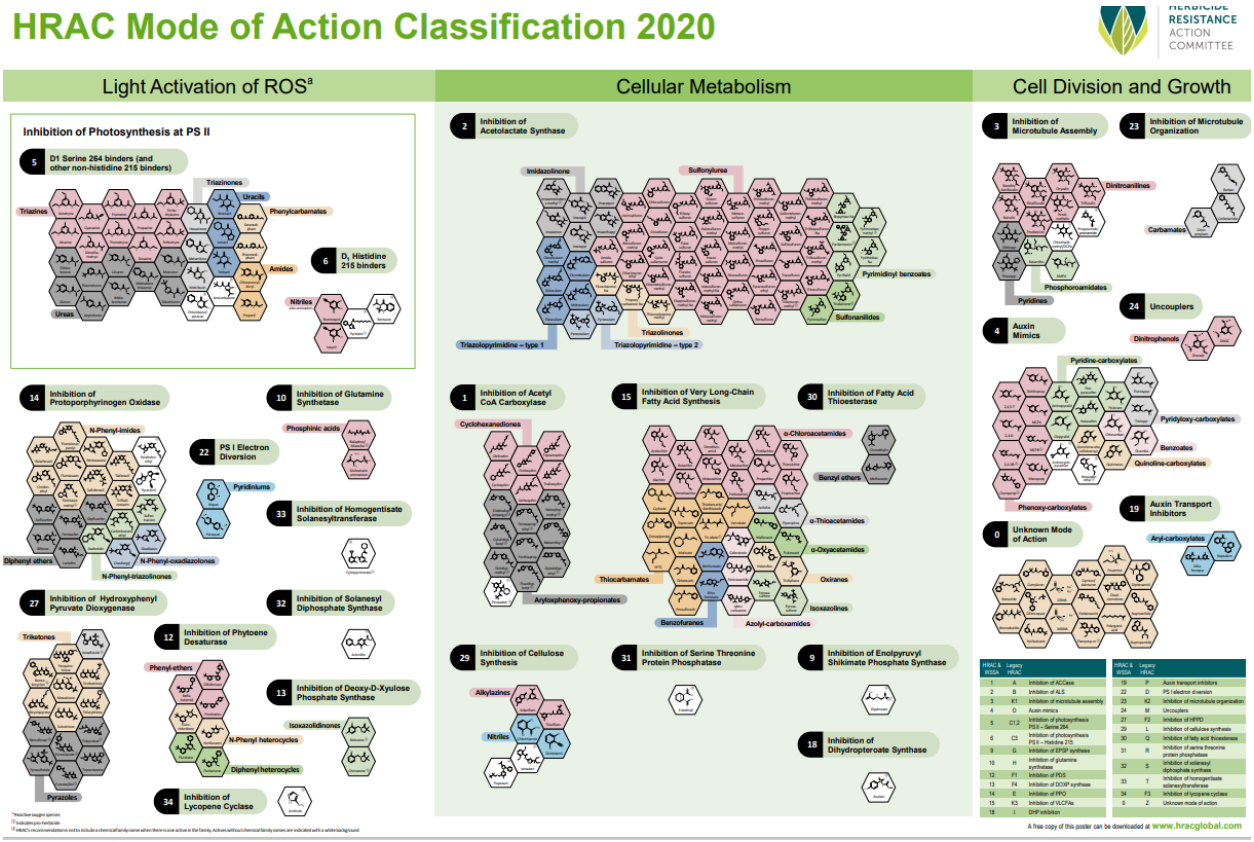

Figure 1. Current herbicide classification according to the Herbicide Resistance Action Committee. Herbicide modes of action are grouped according to the general ways in which the cause damage to plants: 1) the generation of reactive oxygen species, 2) disruptions in cellular metabolism, and 3) disruptions in cell division and growth. For more information about MOA and to download a PDF copy of this poster, visit the following website:

https://hracglobal.com/files/HRAC_Revised_MOA_Classification_Herbicides_Poster.pdf

Sweet Corn IPM, What's New

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Background

Fresh Market sweet corn is an important component to many diversified farm operations in New England. Few crops say "summertime" better than a just picked ear. As vital as sweet corn is to completing the farm stand product lineup, it does present challenges to production. Sweet corn is favored by several insect pests that either overwinter in our region or invade from more temperate zones. Growers employ a variety of approaches to combat detrimental insects. The use of several tactics combined to work towards the goal of insect control is known as *Integrated pest management*.

Brief pest descriptions

In and around New Hampshire, the top three insect pests are European corn borer, corn earworm and fall army worm.
European corn borer is a major pest that successfully overwinters in northern New England. It typically emerges in early June to early July in New Hampshire with two peak flights observed. Damage is primarily done by larval feeding at the whorl stage characterized by a "shot hole" appearance once the leaf unrolls. Larvae also cause damage by tunneling into/breaking off tassels and stalks as they emerge from the whorl.
Corn Ear worm cannot overwinter successfully in our region and blows in every year from southern states. It typically hits our area sometime in late June to early July with variances from year to year. Female moths seek out green silk to lay their eggs. Once hatched, larvae feed on the fresh silk while working their way down to the ear tip.
Fall Army worm is another weather driven pest that typically arrives sometime in late July or August, but again, this is variable. FAW Moths that blow in prefer to lay eggs on younger corn and subsequent larvae heavily feed on leaves, tassels and ears. The larvae leave behind copious amount of frass that resembles sawdust.
A Newer pest of sweet corn is Western Bean Cutworm that has been on the scene in NH starting around 2010. It is a later season pest that can cause significant damage like that of CEW. It feeds on the kernels and can open up the ear to future mold issues. So far, gathered trapping data suggests only one generation per year.

NH sweet corn IPM monitoring program

Monitoring of the key sweet corn pests is essential to maintain positive control while simultaneously reducing inputs. UNH Extension has been monitoring sweet corn in New Hampshire since 2006. One primary goal of the program is to provide trapping and infestation data to growers, partners and the public. This helps growers make insecticide application decisions based off real, local numbers in conjunction with thresholds established by Extension

staff. It marks a move away from calendar-based insecticide applications towards data driven decisions. Trapping information is also shared statewide and beyond with cooperating agricultural service providers that contributes to the regional pest information landscape. Pheromone trapping is used to monitor adult moth numbers. Two styles of trap are used, Heliothis and bucket style. Weekly moth catch numbers and field scouting methods are used to determine if sprays are necessary, based on threshold tables linked in the reference section of this article. Trapping and crop damage numbers are gathered and recorded by our IPM Scout and collaborating "call in" growers who monitor populations on their own. The data is then disseminated by various extension staff from there. The summer of 2022 proved the value of monitoring programs once again with the observation of atypical insect emergence times, likely due to severe drought conditions experienced by much of the state. Growers were able to better time sprays to target insects only when thresholds were reached. Sweet corn was also still being harvested past mid October 2022, which could indicate longer growing seasons in the future. This further highlights the value of a local trapping network that can provide data outside of "typical" harvest times. Going forward local data will continue to serve growers and agricultural service providers well as our weather patterns will likely remain erratic.

Practical considerations to improving an on-farm sweet corn IPM program

As discussed, pest monitoring is the cornerstone of any successful sweet corn IPM program. Moreover, there are many decisions that growers can make that will increase the odds of effective control. Sprayer maintenance and calibration is crucial to proper insecticide coverage and rates. Equipment choice can have an impact; high clearance boom sprayers can be used to effectively apply products to late whorl stage corn. A high clearance boom sprayer equipped with drops nozzles can effectively apply product to corn silks. If cannon type or air sheer sprayers are to be used, it is important to have narrow blocks. 12-16 rows should be the max used. The fewer rows the better when it comes to spray penetration. Transgenic Sweet corn can be an option for growers who are agreeable to these types of products. Some varieties can be very effective in controlling ECB, while less effective in controlling CEW and FAW. It might be wise to first determine consumer acceptance of modified varieties in your area before planting. In New Hampshire there has been growing adoption of no-till systems in sweet corn production. While this serves to forward soil health and other conservation goals, it has had the unintended consequence of providing ECB with suitable overwintering habitat. It is important for no till growers to thoroughly incorporate corn stubble via flail mowing or similar process to reduce ECB overwintering success. Residue from conventionally grown corn should be thoroughly incorporated for the same reason. In some situations, no till systems can have the potential for increased wireworm pressure. Grasses (either as cover crop, volunteers or weeds) creep there way into no till systems and can provide habitat for wireworms.

Future sweet corn IPM program steps

Consumers and producers in New Hampshire are both interested in reducing pesticide usage and preserving beneficial insects. This is partly achieved by using trapping data to spray only when necessary. The next frontier for the program is to integrate "softer" chemistries in current spray rotations. During the summer of 2022, UNH extension staff coordinated four on-farm demonstration plots that integrated a diamide insecticide (Coragen*) into existing CEW rotations

(i.e. traditional pyrethroid rotations). Coragen was placed first in the rotations with the rationale being that this would help preserve beneficial insects further into the growing season. It is important to note that this was not designed to be an efficacy trial but rather a hands-on way to gauge grower interest in alternative spray rotations. At the conclusion of the trial the four growers involved stated they would consider using "softer" chemistries in the future (noting that product costs and container size were the main barriers of adoption) This underscores that producers are looking for ways to mitigate unintended consequences of pesticide usage. As new chemistries become available a goal of the program will be to encourage their adoption, if determined to be appropriate.

Acknowledgements

I would like to thank Jeremy Delisle, Dr. Anna Wallingford and Linda Kunhardt for all their assistance and mentorship. I would also like to thank George Hamilton in particular for his tireless effort over the years that went into the NH monitoring program and for his mentorship.

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** Any reference to commercial products, trade or brand names is for information only, and no endorsement or approval is intended. Always read all pesticide labels carefully. The label is the law! The user of this information assumes all risks for personal injury or property damage.*

Use of the seafood byproduct chitosan for management of apple diseases in the northeast

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Management of tree fruit diseases in the northeastern region of the U.S. is challenging due to ideal climatic conditions for pathogen spread and infection leading to devastating losses. The University of New Hampshire has a legacy of tree fruit research including the pioneering work of Dr. MacHardy to help develop disease forecasting models and integrated pest management (IPM) strategies that combine cultural, biological, and chemical strategies to limit crop loss, reduce pesticide, and mitigate fungicide resistance risk in apple production [1,2]. Even with these advances, New England growers continue to battle fruit diseases. NH growers primarily market retail sales of fresh fruit by farm stand, pick-your-own, and direct sales to grocery stores. As a result, diseases affecting fruit quality are a significant concern. The success of an IPM program is only as good as the tools available and our knowledge of how to use these tools most effectively. Therefore, it is critical for growers to have a diverse set of tools in their "toolbox". One strategy of IPM is to incorporate alternative products such as natural compounds and biologically based fungicides to use in rotation with chemical fungicides.

Chitosan, a natural derivative of chitin, is one of the more promising compounds and is well documented for its anti-fungal activity and disease suppressive properties [3,4]. Chitosan is one of the most abundant polymers on earth and is an important component of all insect and crustacean exoskeletons. Some companies have begun utilizing waste from the seafood industry as a source of chitosan for use in agriculture as a new crop protection product. The efficacy of postharvest application of chitosan to prevent disease and extend shelf life of perishable fruits has been well documented [5–7]. Less is known about the potential of pre-harvest application of chitosan to suppress disease during the growing season and if chitosan acts synergistically with standard fungicide spray programs [8]. The objective of this research was to identify the utility of chitosan as a tool to manage diseases of apple during preharvest and postharvest and identify synergisms with conventional and biological fungicides. In collaboration with extension plant pathologist Dr. Kari Peter at Penn State University, Poleatewich lab doctoral student Liza DeGenring conducted research at the Penn State Fruit Research and Extension center and on NH grower farms to answer two questions.

1. Can foliar applications of chitosan alone or in combination with biopesticides reduce preharvest diseases of apple? We evaluated a commercial chitosan product applied alone or combined with a program of reduced risk materials typical of northeast orchards. The experiment was conducted at the Penn State Tree Fruit Research and Extension Center (FREC) in Biglerville, PA in 2021. Treatments tested included (1) water control, (2) standard fungicide program (Mancozeb + Captan), (3) reduced risk program (sulfur + Serenade ASO), (4) chitosan product (Tidal Grow), and (5) reduced risk + chitosan. Treatments were applied to semi-dwarf cultivar 'Law Rome' grafted on M.7 rootstock and were arranged in a randomized complete block design with six replications. Throughout the season leaves and fruit were evaluated for apple scab and powdery mildew symptoms. We also evaluated for symptoms of summer fruit rots and rots that remain dormant and appear in storage. Leaves and fruit from trees treated with

the reduced risk program and the chitosan + reduced risk program had lower incidence of apple scab and powdery mildew symptoms were comparable to the Mancozeb + Captan treatment. While the chitosan alone treatment did not reduce incidence of disease, severity of symptoms was significantly less on fruit treated with chitosan compared to the control.

2. Can chitosan applications reduce postharvest diseases of apple?
Incidence of summer rots were evaluated at harvest from the FREC research trials and none of the treatments had an effect on disease incidence compared to the water control. This could be due to the low amount of fruit rot observed in 2021. To evaluate decay in storage, fruit were stored at 2°C four months and evaluated for symptoms. Only the Mancozeb + Captan treated fruit had less disease compared to the water control. Latent rot incidence (rots that developed after being taken out of storage and left at room temperature for 11 days) was less on fruit treated with chitosan or Mancozeb + Captan compared to the water control.

Additional research was done to evaluate the efficacy of chitosan postharvest using postharvest inoculations. Fruit were collected from local farms in NH and dipped in a commercial chitosan product or water. Next, fruit were inoculated with two common fruit rot pathogens, *Colletotrichum fioriniae* (causing bitter rot) and *Penicillium expansum* (causing blue mold). We found that fruit treated with the commercial chitosan had significantly smaller bitter rot and blue mold lesions compared to the water control.

Conclusions

Our research suggests that chitosan may have potential as a new tool for growers to use as part of their IPM programs to manage fruit and foliar diseases of apple. However, additional research is needed to investigate application rate, application timing and compatibility with other grower practices.

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Apple variety grower panel

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Good morning, without delay, I would like to introduce our grower panel, but I have to tell you, I had three questions for them, whether they choose to answer specifically is up to them, you know how hard it is to herd cats! But here are the three questions, we will see how close they come to answering them at the end!

1. What's YOUR experience growing new and maybe no-so-new apple varieties?
2. What's your current 'killer' (i.e., still not growing enough) apple variety(s)?
3. What do you see in the crystal ball of new apple varieties?

We're not just growing Macs and Cortland anymore!

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Hello, I am a 2nd generation fruit grower who previously worked growing and selling wholesale apples (250 acre) in western New York. We are presently operating a 25 acre retail pick your own fruit business in Farmington, New Hampshire.

I will cover apple varieties that work well for the PYO market. Pest, nutritional, and crop load management considerations that can be influenced by certain varieties will be discussed along with how I use growth hormones to better manage our apple orchards.

Remember when scab was our biggest apple growing concern? Macintosh and Cortland were popular varieties for a reason here in New England. Annual production combined with winter hardiness and a grower friendly tree made them both fairly easy to grow, all we had to do was spray fungicides all spring. At least then you knew the tractor time was well spent, now we spend more time spraying a multitude of products all spring and summer while all the time questioning if any of it is actually doing anything.

Fire blight management and hormone applications are now the two major factors dictating spray schedules in our apple orchards. Scab materials just get thrown in the tank with them.

Major concerns dictating our varietal choices:

- harvest timing- In PYO you are selling the farm visit. I want ripe apple availability every day late August through late October, variety not as important as when it is ripe.
- got to have: Macs, Cortland, and Honey Crisp (represent 47% of our acreage)
- always try and have a baking apple available
- customers like variety

APPLE VARIETIES/HARVEST TIMING/HORMONE APPLICATIONS/ CUSTOMER APPEAL

Butternut Farm LLC Farmington, NH

Pick your own varieties we grow

variety	harvest	Retain/inc frt set	apogee	Xtra rtrn bloom	Cust like?	Grower comments
		1st flower ¾ pac/acre 1 application	Begin late bloom 4oz/acre + surf 3 applications	Ethrol 1pt/acre Naa 5oz/acre 2 applications		
Ginger Gold	8/25	yes	yes		yes	Vigorous tree
Zestar	8/25				yes	Easy to manage/ productive
Sansa	8/28				yes	similar to Gala/thins easy
Prem HC	9-1	yes	yes		Of course	As frustrating as the original
Macs/corts	9-10	yes	yes		yes	Reliable
Gala	9-10				yes	
Day Br Fuji	9-15			yes	Yes/no	Very biennial
Honey Crisp	9-15	yes	yes	yes	Of course	Pain in the &*#@%
Pixie crunch	9-25				yes	Smaller apple/ productive
Macoun	9-25		depends		yes	
Empire	10-1				yes	Great apple/easy to manage
Snow Sweet	10-5				Want more	Productive/annual
Red Del	10-5				surprisingly	
Shizuka	10-5				growing	Similar to mutsu/sweeter
Jon a Gold	10-5					Bitter pit susc
Mutsu	10-10				Lyl followin	
North Spy	10-10			yes		
Gr Smith	10-20					Never really ripens complete
Aztec Fuji	10-20			yes	yes	Never really ripens complete

Return Bloom for all varieties: 2 applications of Vitazyme @ pink and 1st cover, 2 applications of naa 5oz/acre @ late June + 2weeks

Varieties we grow but are not on replant list: Hampshire, Acey Mac, Jersey Mac, Sun Crisp, Barnsby Pink Lady

How much do apple varieties really matter? PYO vs retail balance?

Chelcie Martin
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I am a fourth-generation farmer running Honey Pot Hill orchards with my father Andrew Martin. Our 200-acre orchard mainly consists of apples, peaches, pears and blueberries, with some vegetable crops.

We love growing good fruit. It's our thing. But there are many challenges, including weather, pest management, customer satisfaction and the focus here, what fruit varieties to plant that will work for all involved, including us as growers and for both our retail market and PYO.

Location, Location, Location…We have noticed that whatever the variety is, the closer it is to the parking lot, the faster it gets picked. Obviously, this counts double if you have a desirable variety next to a parking lot (our Honeycrisp planting up against parking lasts about two hours).

I am writing this as we enter November and the apples that we have left are in the far reaches of our orchard. People have foregone Mutsu and Jonagold to pick Red Delicious because it saved them a 20-minute walk.

People are always willing to walk for Honeycrisp. We have also seen a large contingency of people willing to hoof it for pears.

Our hottest new varieties are Smitten and Ambrosia. We opened our first Pixie Crunch this year and people seemed to really like them. Evercrisp are an absolute smash hit in the farm store, but very dicey as they ripen so late in the season you risk losing a crop if the weather turns.

Honeycrisp are always desired but are such a pain to grow, we are planning on just maintaining the acreage we have right now.

Love your fruit as much as we do!

Bill and Rupert Suhr
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After receiving my BS in Forest Biology at the University of Vermont in 1994, I purchased a 60-acre fruit farm in 1998 in Shoreham, Vermont and pedaled apples with a station wagon the following year. Now, with wife Andrea Scott, and 11-year-old son Rupert and 9-year-old daughter Rosa, fruit is grown on 350 acres vertically integrated business Champlain Orchards, including tree nursery, 100,000 bushels Controlled Atmosphere storage, packing/processing, and refrigerated delivery. With the help of 50 year-round employees and 40 seasonal part-time employees, two on-farm markets with coinciding PYO offerings represent 7% of gross revenue with 93% wholesale with direct deliveries to supermarkets, food coops, and institutions. Products include year-round availability of Champlain Orchards ecologically certified fresh fruit, sweet cider, hard cider, apple pies, apple butter, cider donuts, apple sauce, cider syrup, maple syrup. Rupert Suhr, owner of R&R nurseries propagating elderberry, lilac, currants, gooseberries, sugar maples, and herbs for sale online and through on-farm markets. He also oversees annual Champlain Orchards nursery rootstock/ varietal matches and field nursery horticulture.

Diversification of fruit offerings – 150 varieties of apples, along with numerous varietal offerings of pears, peaches, nectarines, cherries, plums, grapes, and berries – presents challenges and opportunities with many choices. How do we decide what to plant and market? Do our customers tell us? Rupert -- who is responsible for horticulture and expansion of PYO crops including grapes, raspberries, elderberries, gooseberries, currants, blueberries – is inspiration for continued growth and refinement of existing business of Champlain Orchards. Family owned and ecologically managed, we are careful stewards of our land and grow all our fruit following strict Eco-Apple requirements, while striving to minimize our carbon footprint and sustainability contribute to our community.

We think of wholesale and PYO differently. For wholesale we need color variability especially green/yellow apples to help with color breaks in displays. PYO customers want either sweet or tart, they then might ask for fresh vs baking/saucing, third most popular question is best for home storage/keeping.

I would like to share primary apples we are offering early, mid and late season. Within that there are then categories with seasonal options such as disease resistant, heirloom, new, unusual, cross over apples (fresh and for fermentation) and hard cider specific.

I would also like to say that diversity is great and folks are coming to us for the broad offering which stimulates curiosity and results in an educational opportunity. On the wholesale level only certain cultivated customers remain stimulated year round by the unusual varietal offerings. Large retailers often revert to their core offerings when shelf space diminishes with citrus etc.

Champlain Orchards goal is to keep "top of mind" offering a fantastic eating experience year-round and banking on customers remembering the experience and returning to seek more. We want to be a supplier of exceptional eating experiences of ecologically grown fruits with reasonable travel distance to our consumers.

We will have visual images of each apple along with a description to aid in the presentation. Will also try to focus on just apples.

21st century apples: MAIA and more!

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Hello, I served as Professor and area Extension fruit agent from 1978 to 2016 when I retired from Rutgers University and started Win Enterprises International, LLC, a private consulting and contract research consulting company. I specialize in pome and stone fruit horticulture but am also well versed in pest management. I am the editor of Horticultural News (NJ State Horticulture Society) and associate editor of Fruit Notes (UMass). I currently works closely with Wafler Nursery and Midwest Apple Improvement Association (MAIA) 21st Century Apples.

Many new apple varieties are out there, so how do you pick? Some are available to all, some are managed, and some are very much newcomers. I will talk about my favorites, focusing on some of the newer MAIA apples, and which should be on your radar screen for both retail and PYO sales.

Of course, selecting new apple varieties for your production is the big challenge. Considerations include what is your marking program? i.e., what will these apples be used for?

Fresh market/farmstand/farmers market, PYO, wholesale (fresh or processed), or cider (sweet and/or fermented).

Retail sales means different things to different growers, there are many avenues for retails and many combinations of them all. Our best New Jersey growers use them all to capture the retail and value-added dollar. These include:

- Roadside markets (or multiples)
- Tailgate farmers markets in towns and cities, sometimes in multiple states (some growers do 15+ tailgate markets)
- PYO (some multiple locations)
- Roadside wholesale trade (selling to other retailers) sometimes called bin trade
- Wholesale

MAIA selections and varieties are making a big impact!

- MAIA-SM (SweetMAIA®)
- MAIA12 (Summerset®)
- MAIA11 (Rosalee®)
- MAIA-12 (Ludacrisp®)
- MAIA1 (Evercrisp®)

Other newer varieties to trial/plant:

- KinderKrisp
- Pixie Crunch
- Crimson Gold
- Autumn Crisp (NY674)
- Ruby Rush (NJ150)

Other varieties new and old as must plants

- Gala cv. 'Pitts Gala'
- Crimson Crisp (PRI Coop39)
- Stayman Winesap
- Goldrush (PRI Coop 38)
- Cripps Pink (cv. 'Barnsby')

Mechanical Harvesters

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Once we started to scale up on our farm, we quickly saw the need for mechanical harvesting to reduce labor, take advantage of short harvest windows, quickly get crops harvested at the right time and temperatures, and push us from bag or tote harvesting to bin harvesting.

Root and tuber harvesting

We currently mechanically harvest, carrots, beets, turnips, and potatoes with a combination harvester that top lifts green tops of carrots, beets, and turnips. An additional unit for that harvester can also dig potatoes and carrots. Prior to this we used a 1960s American made carrot/beet harvester. This mechanical harvester was a great introduction for us and allowed us to scale up our root production dramatically through the years. With our current root/tuber harvest unit we can harvest 6-8 bins per hour with a two-person crew.

Greens harvesting

We primarily use a walk behind greens harvester that can cut a full 48 inch beds width of salad greens. We harvest with this unit in the field during summer months and in our hoophouses during winter greens production. This harvester utilizes a bandsaw blade to cut the greens and a conveyor which moves the greens up to a platform and into totes. We also use the Farmer's Friend handheld greens harvester to trim up ends of beds, outside edges, or when we are only harvesting a small amount of greens (20-50 pounds).

With the walk-behind harvester we can harvest a 100-foot bed of greens in approximately 10 minutes (2 people working 5 minutes each – one operating the harvester and one moving totes and harvested crop). So in about 1 hour a team of 2 can harvest a 30x100 ft hoophouse with five, 95 foot seeded beds, yielding approximately 350 to 500 pounds of baby salad greens (depending on the variety).

Mechanical Harvester pros

- Pushes you to achieve cleaner crops in the field. A fairly weed free crop of roots and greens is a joy to harvest and the wash crew is much happier with the product.
- A clean, quickly harvested crop can increase your profits
- Mechanical harvesting equipment is less taxing on your body
- Cuts for greens are complete (little wasted in cutting) and clean so regrowth quality is good

Mechanical Harvester cons

- Cost of equipment is a serious consideration and a factor in ROI
- May require more acreage of land for harvesting/rotation

- It helps to be mechanically inclined to address the myriad mechanical issues that can arise with the machines.
- Quick and efficient harvesting with these machines can lead to bottlenecks further down the line on your farm, specifically in the wash house and packaging.

Equipment Innovations for Cover Cropping and Reduced Tillage

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Root 5 Farm is a 38 acre organic vegetable farm located in Fairlee, Vermont along the banks of the Connecticut River. The soils are mostly Hadley, sandy loam. We grow about eight acres of mixed vegetables and six acres of cover crops each season with the rest of the acreage in wooded slopes and roads. Our bed dimensions are six foot wide by 100 and 200 long foot beds. We sell our vegetables through a 400 member CSA program and to local co-op grocers and restaurants.

Due to preexisting high phosphorus levels found in our soils we have focused on using cover crops to grow nitrogen and organic matter. We supplement with bagged amendments for our fertility program and soil health benefits. In recent years we have set about to improve our cover cropping and bed preparation systems. Below are a few of the techniques we have focused on.

Cover Cropping Innovations

We started out using a cone spreader or flinger bag to seed cover crops, then we would use a brillion to press it down or a field cultivator set very shallowly to cover the seed. There are advantages to this system. The tools are relatively inexpensive and available. A cone spreader can be used for spreading lime or other amendments and a brillion can be effective at spreading small sized covers such as clovers.

The disadvantages to the system are that it can take multiple passes with two pieces of equipment to accomplish the job. This leads to more soil structure degradation, time waste, increased equipment use, and organic matter reduction. It can provide a poor seed to soil contact leading to poor germination and poor cover crop stand allowing weeds to proliferate. A big challenge with this system is that it is dependent on rain or soil moisture to get a good stand as well. Among other things happening in 2020 we had a difficult dry mid summer resulting in dry conditions that led to poor germination and wind blown almost dust bowl conditions as a result of our cover cropping equipment's inability to produce good stands of cover crops in more frequent challenging conditions.

The question arose of whether we could do things differently. What changes can we make to result in less passes with the tractor, while growing a better cover crop stand (in spite of the conditions that have continued), and be more precise with the seed we put out onto the land possibly with less effort.

We had a hunch and a bit of cash to throw at the problem and figured that a grain drill might be able to answer this question effectively. We purchased a Great Plains 3P600 grain drill. It has 9 rows 7.5" apart with a large seed and small seed hopper. It is 6' wide allowing us to seed one bed if needed. It is also a 3 point hitch which allows greater versatility in tighter spaces that exist on our farm.

The grain drill is a minimum till drill with coulters to cut through chaf and rougher beds. This feature is present on all drills but is very effective on this drill and more effective than our past methods. It also has press wheels for better seed to soil contact. A feature not present on many older grain drills from what I could tell. This connects the seed with the soil moisture that exists at depth even during drier conditions giving it a better chance of germination once seeded.

We've been very pleased with the new drill and wish that we would have gotten a drill sooner. It is more precise and user friendly than other methods described. It has allowed us to make fewer passes than the old systems. We can also cover one bed at a time as we come out of successional vegetable crops throughout the season. It leaves the soil conditions rougher and in a better position to exist in the hotter drier weather that we have had in the last three years. Now it is up to us to keep using it to keep the soil covered whenever possible.

Bed Preparation Innovation

Tarping

We have been silage tarping for a number of years. There are many upsides and downsides to the tarping system but we have found the reduced need for stale seeding, nutrient retention, and weed suppression to be worth the effort to continue the practice.

Stone Burier

This year we added a stone burier to our system attempting to answer the question of reducing the number of passes needed to form a direct seedable bed while maintaining our attempts to continue to use robust cover crops. In the past we've used a chisel plow, disc and field cultivator to form beds for seeding. This system would often leave plenty of soil structure intact but also left a bit of cover crop residue that made direct seeding and paprepotting difficult. The stone burrier allows us to create formed beds with what might be called trash or the remnants of say, rye to be pushed to the bottom of the tilled bed area. So far so good. While not the magic bullet it is another effective option in the tool array.

One question to be answered still is whether this tool will lead to a reduction in organic matter (a primary concern of ours) as it is essentially a rototiller by another name. Like all things if it is a good thing there is probably a hitch to look out for. As a result also should be used only when necessary. As a result we have been trying to figure out a happy place for transplantable crops and paper potted plants in connection with the use of this tool.

Strawberry Variety Update – A Nursery Perspective

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Presentation – New England Berry and Vegetable Growers Meeting - Dec. 13 - 15th. (30 Minutes)

Good morning - I appreciate the opportunity to make this presentation to you today.

When David asked me back in April if I would make this presentation, I said I would be presuming that I would still be alive and kicking. I believe that this organization and conference is among the best that we belong to and attend. We will do anything to support this to guarantee its continued success.

My talk today is an update on strawberry varieties from a nursery perspective.

We have had no new varieties since we offered Dickens back in 2018 for trial plantings. But we are Importing several interesting new varieties to test now. So there are several new varieties on the horizon.

So the main part of my presentation will focus on our leading varieties and their performance reported to us by our growers/customers.

For the early ripening group, Wendy and Galletta have taken over in popularity, although Annapolis and Earliglow remain in demand because of their particular traits. It appears to me that growers chose Wendy or Galletta based on their soil types and the flavor they experience. Both varieties have good characteristics, with Wendy being slightly earlier than Galletta. Under our conditions we prefer Galletta because of its great flavor and its ability to hold size under our conditions. Annapolis is a tough variety that preforms in heavier soils and under cold climate conditions in the upper mid-west and other northern locations. Where Earliglow has its outstanding flavor. As a result, it has a strong following by PYO customers that maintains its popularity with growers.

In the early-midseason group of varieties, Yambu and Honeoye are the varieties in highest demand but Cavendish and Brunswick remain popular because of their special attributes. Yambu has gained rapid popularity because of its high plant vigor and improved flavor over Honeoye. Honeoye stays relevant as it will grow under a wide range of conditions and its high production. But Cavendish, being best adapted to northern conditions, is very productive with good flavor. It is my opinion that if it wasn't that Cavendish had the un-even ripening syndrome under high temperatures, it would be as popular as Jewel. Brunswick also has better flavor than Honeoye and fits into many growers' program because of it's disease package and performance.

In the mid-season group of varieties, Jewel remains the leader and the top selling variety for our production. Its consistent performance is the reason that Jewel remains so popular. Flavorfest continues to increase in demand because of its disease resistance and its ability to hold berry size. But Darslect, Allstar and Sonata also remain competitive varieties. Darslerct has more management issues to deal with but it is highly productive and hold berry size very well. Allstar remains a work-horse variety performing under a wide range of soil conditions, especially heavier soils and its disease resistance. Sonata is a very flavorful variety that requires extra nutrition requirements with magnesium and nitrogen management.

For the late mid-season Cabot is the leading variety in this category. It has very large fruit and good flavor. It requires a high level of boron to reduce the amount of mis-shaped fruit. Where Dickens, Sparkle and Mayflower fill in growers' production needs. We introduced Dickens in 2018 and it has been increasing in popularity because of its firmness and easy picking habit. The flavor is good. Sparkle is the oldest variety in our list being over 80 years old. It is still be planted by northern growers. Mayflower is a productive and durable variety, but lacks flavor. We have stopped propagating Mayflower as a result.

AC Valley Sunset is our only late variety. As it's our 5th most popular variety, it is well accepted for its high quantity fruit and vigorous plant.

We categorize Malwina to be a very late variety. It is out 4th most demanded variety because of its late season and high quality fruit. We experienced a production problem with Malwina for the 2022 sales season, but expect to be back in full production for planting in 2014.

If you have any questions contact me at my email: tnourse@noursefarms.com

Strawberry Weed Management – Getting Started

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Proper site and soil preparation for strawberries is critical for successful establishment of a new planting. Preventing weed problems in the planting year will be one of greatest challenges of getting the new bed established.

The first step in managing a weed problem is to prevent it from getting started. Select a site where the weed pressure, especially from perennial weeds, is low. Choose a site that has previously had cover crops and/or cash crops in which weeds were well-managed. Do not plant strawberries into recently plowed perennial grass sod. This can lead to devastating weed problems from species such as quack grass and clovers.

Planting new crowns late in the spring as opposed an earlier planting date can be used to manage an early flush of weeds in a new strawberry bed. Prepare the ground for planting in the fall or in the early spring, then allow the first flush of spring weeds to germinate before planting. You can then eliminate those early spring weeds with a light cultivation, a contact herbicide or flaming, and then plant the strawberries. By eliminating the first flush of weeds and planting into a warmer, drier soil, the need for early cultivation and hand weeding is greatly reduced. However, delaying planting by the four to six weeks needed for this practice can reduce the quality of your stored strawberry plants. Discuss any delayed planting plans with the nursery in advance so that they can store and ship the plants at the best time for you. Late planting also shortens the length of time the new plants have to develop and form runners to fill out the bed, but experience has shown that plant populations are usually adequate by season's end. Increasing the in-row crown spacing a few inches (e.g. 12" between plants) can also compensate for fewer runners where this is a concern.

Strawberry beds are typically planted on open ground following the incorporation of a cover crop. Weeds are then managed with a variety of cultivation methods such as tine cultivators, blind cultivators (e.g. Lely) and/or finger weeders (e.g. Buddingh, Regi). This can be effective early in the season, as long as it is combined with vigilant hand weeding within the plant rows, where the cultivators can't reach. However cultivation becomes more challenging during the summer when the plants runners grow into the path of cultivators. Using sweep blades to push the runners out of the way in front of the cultivating tines can work, but generally the need for hand weeding will become more intense as the season progresses. Flaming weed seedlings between the rows may also be used in strawberries, but it is costly, and the burners must be well-shielded to prevent burning the strawberry plants. Flaming has the advantage of not disturbing the soil surface, and thus reduces further weed germination.

Tarping can also be used to eliminate the first flush of weed growth in a new planting. After soil preparation in the fall or early spring, plastic tarps laid over the soil surface for as little as four to six weeks can significantly reduce subsequent weed seed germination. The tarps must be well-

anchored to prevent the wind from disturbing them. The size of the tarp available will limit the size of the area that can be treated. Planting following removal of the tarp should disturb the soil surface as little as possible to prevent bringing up more weed seeds.

Another strategy for managing weeds in the planting year is to use strip or zone tillage. A heavy cover crop of oats or winter rye is seeded during the late summer the year before planting strawberries. Oats will winter kill, but rye will need to be crimped, mowed or killed with a contact herbicide the following spring. The plant residue is left undisturbed on the soil surface except for narrow (8-12") strips or zones that are tilled for the strawberry plants. Leaving most of the soil surface untilled with a heavy plant residue prevents most weed seeds from germinating. The rye residue last longer than oats, but killing the rye can be problematic. Zone tillage requires specialized equipment to make the soil strips suitable for good plant growth. The equipment is both expensive and heavy, requiring a fair amount of horsepower, but it can be used for many crops on the farm. Toward the end of the season, as the residue breaks down, weeds can once again become an issue, and hand weeding will be required within the tilled strips of the plant rows. After harvest the following spring the planting is usually plowed down and the field put back into rotation crops for a minimum of three years.

Plastic mulches are also being used to reduce weed problems in strawberries. Planting strawberries through black plastic eliminates much of the weed pressure within the planting, but prevents the use of runner plants to fill out the row. Therefore, plasticulture systems require about two to three times as many plants as a matted row system at planting, and plants are initially spaced only 8 to 12 inches apart. Once again, specialized equipment for making beds and laying plastic mulch is required, but vegetable growers would likely have such equipment available. In a plasticulture system, strawberries are typically planted later in the spring or early summer to reduce runner production. Runners should be removed in this system, which is quite labor intensive. The plants are overwintered and harvested the next spring. After harvest the plastic is removed, and the planting is generally plowed down. Research is underway to evaluate the feasibility of cutting and removing the plastic in the second season and allowing the planting to become a matted row for harvest a second year. It is hoped that weed problems would be reduced from having the soil covered for the previous year.

Most organic strawberry growers using the matted row system have found that the beds should only be fruited one year then plowed down and put into rotation crops. Trying to renovate a bed and carry it over a second year inevitably leads to major weed infestations and increased insect and disease pressure. However, using a plasticulture system in the first year and converting it to a matted row for a second year with minimal soil disturbance could provide a workable two crop system that would significantly increase the profitability of the planting.

The one harvest year rotation is probably still the best option for most organic growers (plant year one, harvest year two, plow down and plant to rotation crops) to manage weed problems in strawberry beds. However, some of the new strategies being developed may allow growers to extend the productive life of strawberry beds and thus improve their profitability. With any new strategy, it is critical that strawberry growers maintain soil health and fertility and prevent the build up of pest organisms; therefore each new technique must be evaluated not only in terms of how it affects short-term yield, but also how it may impact the long term success of future crops.

Overwintering Flowers for Early Season Blooms in the Northeast

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The cut flower trialing program at Johnny's Selected Seeds operates on our research farm in Albion, Maine. Along with conducting variety trials for seed-grown annuals, perennials and flower bulb crops, we also conduct trials on growing methods. For the past six years the flower trialing team has been exploring season extension for cut flowers by overwintering flowers in unheated tunnels.

Our field-growing season in Zone 5 in the northeast excludes us from field flower production for important spring floral holidays – Valentine's Day, Mother's Day and Easter. We do not typically harvest field-grown flowers until late June or early July. Our long winters create a real hunger for color in the spring, so even without the holidays, growers with earlier blooms would likely find markets in the northeast. Growers in milder climates (the Southeast and the Pacific Northwest) overwinter cool-loving flowers in the field and/or unheated tunnels and harvest earlier to hit important floral holidays. Our goal was to explore the possibilities for early-season flower production in the northeast in Zone 5, with Mother's Day as the target for spring flowers.

We began trialing in the fall of 2016 and focused our trialing efforts on crops that we knew thrived in cooler temperatures such as delphinium, digitalis, snapdragon and sweet pea. We have continued to expand our trialing efforts and have now trialed over 25 different crops in this overwinter tunnel environment. These results are documented on the Johnny's Selected Seeds Grower Library and information can be found in the form of a webinar, trial results and videos on specific crops here: https://www.johnnyseeds.com/growers-library/flowers/growers-library-flowers.html.

For today's presentation I am going to focus less on the "how-to" of overwinter growing, since that is covered in detail in the webinar, and focus more on specific crops that have worked well for us in the overwinter tunnel environment.

Basics of the Johnny's Overwinter Tunnel Trials

We trial in unheated tunnels and cover all crops with AG-70 row cover when the outside temperature is forecast to dip below 32F. We currently trial in a 30x96 Rimol Nor'Easter, although we have used other models and sizes of tunnels over the years with comparable results. We have minimally explored the use of overwintering flowers in the field with low tunnels but results in two different seasons were not as consistent or promising as the overwinter tunnel results so we have not continued trialing in low tunnels. This may be worth exploring for growers in slightly warmer zones.

We grow in Zone 5. Our first frost is typically October 1-10 and our last frost is typically May 21-31. Our average annual extreme minimum temperatures are -20F to -15F. Our target planting date for overwinter tunnel crops is October 15th, at the same time we target for planting field

bulbs. Our target bloom date for overwinter flowers is Mother's Day. After six years of trialing we have succeeded in hitting Mother's Day with overwintered flowers in some crops but not all, and we have found many crops that survive and thrive in this tunnel environment.

The Overwinter Tunnel Environment

The overwinter tunnel provides the following benefits: temperature moderation (especially during the shoulder seasons), a longer rooting time for fall-planted crops and early access to spring sunshine. This moderated environment results in longer shoulder seasons where fall-planted crops can be well-rooted in the tunnel before freezing temperatures set in and are well-situated in the early spring to take advantage of increasing sunlight and start growing, well before the snow has melted outside. This provides an ideal environment for vegetative growth and for crops that thrive in cooler temperature ranges than our field season provides.

Why Overwinter?

Although results vary by crop, we've observed the following benefits from overwintering flowers in an unheated tunnel: earlier blooms (3-6 weeks earlier than field-planted flowers in some crops); a longer harvest window and improved bloom and/or stem quality. This moderated tunnel environment also provides the right environment for some crops we wouldn't grow otherwise as cuts such as pansies. And the overwinter tunnel has been a good environment for some varieties and crops that tend to be a little shorter than desired in the field – the tunnel allows time for vegetative growth that would not be achieved in the field, allowing some varieties like Rudbeckia "Sahara" to reach ample height in the tunnel.

Challenges of Overwintering

We've also experienced challenges incorporating this type of season extension into our flower year. The following challenges are worth considering if you are planning to overwinter flowers:

1) **Seasonal workflow management** at the following times of year: **Spring** – flowers start blooming in mid-April and the tunnel is in full-bloom by mid-May. This requires someone to harvest and process flowers during our busiest time of year for seeding and transplanting all the field annuals. **Summer** – in order to hit the October 15th transplant date, many flower crops need to be seeded in August and September at peak field harvest season. Allocating labor, attention and space for seedlings at this time of year is difficult for us. **Winter** – while minimal growth occurs in the winter, some monitoring needs to take place, including removing row cover and ventilating tunnels on sunny winter days.
2) **Irrigation and moisture management**. While crops aren't actively growing and don't need irrigation during the coldest and darkest months, they often require water when growth begins in late February and early March, before our irrigation systems are accessible.
3) **Scheduling, succession planting and crop maintenance** are also needed. For growers who use their tunnels for summer flower production (dahlias, celosia, etc…) there may be a tight turnaround when overwinter crops can be terminated and summer tunnel crops need to be planted. Plants produce excessive vegetation in the tunnel environment and often need more staking and support than in the field.
4) **Pest and disease pressure** – having living plant material in the tunnel over the winter provides more opportunity for pest and disease pressure. Our primary pests are voles and aphids while most common disease pressure is powdery mildew and downy mildew.

There is also less time and space under this planting system for rotations and cover cropping in the tunnel.

a. Spacing is one thing to consider in managing pest and disease pressure. We space everything 3 rows/bed and 6" or 12" spacing within the rows. I've observed many growers utilizing tighter spacing and this is an area open for exploration depending on your system and disease pressure. We've chosen a wider spacing to try and strike a balance between yield and disease/pest pressure and also to maintain consistency year to year in trials.

Top Performers in the Overwinter Tunnel

Snapdragons. Snapdragon series in Groups 1-4 work well in the overwinter tunnel environment. The Group 1-2 varieties will bloom earlier and slightly shorter, while Group 3-4 varieties will bloom slightly later and taller. Plant series such as Legend, Costa and Potomac at once to achieve a staggered spring harvest. Our first cuts are typically May 10-15 on early varieties (Weeks 19-20) and a second flush is possible if plants are left in the ground. Not recommended: the Rocket series, which tends to stretch and produce very elongated blooms in the tunnel.

Digitalis. Both biennial (Pink Gin, Pam's Choice, the Polkadot Series, Café Crème) and first-year flowering varieties (Camelot, Dalmatian series) work well in the overwinter tunnel. The overwinter environment provides the vernalization requirement for the biennial varieties so they will flower in the spring after a mid-October planting date. The first-year-flowering varieties tend to bloom earlier, followed by the biennial varieties, allowing for a staggered harvest. While digitalis *will* overwinter outside, the benefits of growing them in the overwinter tunnel are earlier blooms (3-6 weeks before our field plantings, depending on variety) and better bloom and stem quality.

Poppies. We have trialed several poppy species in the tunnel and have found *P. nudicale* performs best. Both Champagne Bubbles and Colibri poppies overwintered well. Icelandic Poppies are a crop that really seems to thrive in the overwinter slot – even though early spring plantings perform well too, we've had our best yields and longest harvest window from overwinter plants. We've transplanted as late as November 4th with good results.

Pansies/Violas. This is a crop that we wouldn't grow as a cut outside of the overwinter tunnel. The tunnel environment causes the plants to stretch in the spring, yielding 12-20" tall stems (depending on variety) that are paired with our tunnel tulips and field daffodils. The benefits of this crop are the early blooms and greenery at a time of year when very little is blooming in the field or tunnel. An added benefit is that many varieties bloom all winter and can be harvested for edible flowers, although productivity varies by variety and the severity of the winter. In general varieties with smaller blooms flower earlier and are more productive than large-flowered varieties.

Campanula – does not bloom earlier than spring-planted campanula (both bloom in early June for us) but does provide significantly taller stems and more vigorous plants. Requires additional staking and support due to vigorous growth.

Eucalyptus – we have successfully overwintered seedlings transplanted in mid-October and found the plants vigorous and productive enough to start harvesting in mid-late June. This is about 6-8 weeks before our field-planted eucalyptus is ready to harvest. Plants thrived in the tunnel, reaching over ten feet tall by late October.

The following lists include other crops we have trialed in the tunnel and the primary benefit for growing them or reason for not growing them. More details on these crops can be found at: https://www.johnnyseeds.com/growers-library/flowers/growers-library-flowers.html.

A note on anticipating bloom times: Bloom dates on all crops can shift earlier or later depending on the severity of the winter. Bloom dates listed here represent what we have seen most consistently, although we do observe variability from year to year.

Foliage Options: Pansy and Viola; Sweet Peas; Bupleurum; Bells of Ireland; Dusty Miller.

Earliest Foliage:

- Pansy (mid-April), Sweet Pea foliage (early May)

Earliest to flower:

- Pansy (mid-late April); Poppy (mid April); Dianthus (Sweet series – late April/early May)

Good for a Long Harvest Window:

- Dianthus – extend the harvest by planting Sweet, Amazon and Chabaud types. The Sweet series will bloom earlier, followed by the Amazon and Chabaud series.
- Snapdragon – plant different series/groups for staggered harvest
- Digitalis – plant biennial and FYF varieties for staggered harvest
- Poppies – continuous harvest from mid April through May

Latest to Flower (includes long-day crops):

- June harvests: Matricaria, Rudbeckia, Dara, Scabiosa, Campanula

Would only grow in a tunnel:

- Pansy, Poppy, Stock (spring and fall plantings – not overwintered)

Honorable Mention:

- Stock, Tulips, Eucalyptus, Campanula, Ranunculus

Would Not Recommend for overwintering:

- Did not survive: Clarkia, Breadseed Poppies, Shirley Poppies, Tweedia
- Stock – minimal survival and poor quality; much better for us as a spring tunnel crop
- Yarrow – excellent survival; more vigorous and taller than field planting but not earlier
- Columbine – excellent survival but plants did not bloom in the spring. Likely requires more cold for vernalization than the overwinter tunnel environment provides.

Cut Flowers and Finding the Right Scale

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Finding our farm's scale- An overview:
2008-2013 We spent the first five years farming working for other farmers including dairies, pastured pork, beef and chicken operations. We also experimented in our own enterprises producing and selling specialty greens, eggs, flowers, and veggies.

year	**Farm configuration** **Area in production**	**Sales outlets**
2014 (3 years)	Officially started Understory Farm LLC- pastured pork, vegetable and flower farm on leased land.	-Farmstand -Farmers Market -Pork sales to NYC
2017	Farm Viability Business plan Record keeping Market research *< 1 acre flowers* *Greenhouse in summer only-pigs in winter*	-Pork sales to NYC (declining) -Farmers' Market -Wholesaler -Florists/Designers -Grocery Stores -Farmstand
2018	We liquidate the pork operation and focus entirely on cut flower production. *1 Acre in flower production* *1 greenhouse full time*	-Farmer's Market -Wholesale -Florists/Designers -Grocery Stores -Events/Weddings -Farmstand
019	We nearly doubled our flower production and sales *2 acres in Flower Production* *2 high tunnels plus prop house*	-Farmer's Market -Wholesale -Florists/Designers -Events/Weddings -Grocery Stores -Farmstand

2020	Covid. Purchased our own farm through the Vermont Land Trust *4 acres flowers* *3 high tunnels plus prop house*	-Wholesale -Grocery store sales -Flower shares(initiated in an attempt to make use of flowers we had already planted) -limited Events/ Weddings
2021-2022	*5 acres field annuals, perennials, high tunnels plus prop house*	-Wholesale -Florists/Designers -Grocery Stores -Flower Share -Events

Price per stem for various sales outlets:

Market outlet	**$ per stem**	**specificity**	**Input level of communication**	**Consistency /reliability of sales**	**Quantity per sale interaction**
Direct to designers	$$$	Very high	High (depending on designer)	Not dependable weekly	variable
Weddings	$$$	High to flexible	Very High	variable	Low to variable
Direct to wholesaler	$$	Relatively high	minimal	reliable	high
Flower Share	$$	Very flexible	intermediate	Very reliable	medium
Grocery store sales	$	Very Flexible	minimal	Very reliable	high

Important Elements of Finding Scale:

- **Consistency in Sales and Production -**succession planning and season extension
- **Crop Selection**
- **Efficiency-** SOPS for field and pack shed
- **Mechanization-** weed control, bed prep, transplant, fertilize
- **Insect control**
- **Soil Health**
- **Irrigation**

Greens and Flowers Year-Round For Profit (Zone 4b)

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Brief background of Unity Farm: our mission.

- Started out with a business plan to grow winter kale (Fall 2013)
- Not a farmer. Started with 54 acres that had no infrastructure, road, buildings, etc. Started with (2) 30 x 138 hoophouses. Thought process more as a gardener.
- Mission of the farm is to sustain itself, my horses and 2 employees. Stewardship of the land. Focus on a smaller scale that will produce high quality, sought after product. Stay local.
- Became certified organic in 2016 for everything. Started converting to no-till, both the hoophouses and the fields. Really focused on healthy plants, healthy soil – soil tests every year, worked with U. of Maine and Vern Grubinger; compost tea application; rotate crops; IPM if possible. Have very little insect issues (aphids and flea beetles are the biggest ones) and very little plant disease (powdery mildew on zinnias, peonies, etc. which is expected).
- The kale was successful, but we had to have a bigger diversity of product. Expanded the greens we offered to: kale, chard, spinach, parsley, mustard greens, lettuce (salad mix). Later on added collards.
- By chance fell into growing marigolds and zinnias in 2014 for a friend who owned a florist shop in town and really encouraged me to add flowers to our planting plan. At the time there wasn't a lot of flower growers in the area (Pre Erin Benzakein/Floret Flower Farm). Took off from there in 2015.
- Filled in the gap between end of May/first of June when the farmers markets started up and September when we had greens fresh and ready to go for a fall/winter market. At this point, most field farmers are planting cover crop and ready to wrap up their season.

1. Years 2015 – 2017. Have expanded to 3 hoophouses, one smaller bulb hoophouse and a heated greenhouse for propagation, plus outdoor fields. (About 2 acres). Our thinking was to grow product at the season where we could get the highest price. Continued to grow our market for winter greens, planted a bed of chard and kale outside through the summer, experimented with salad mix but not worth losing the space for flowers. In our area, we start seeding for greens in early February (including a few flowers) , overwinter kale and spinach, start planting into the hoophouses by mid March. Start pulling them out by end of May to make room for more flowers. At this point, we are starting to include bulbs in the equation, mainly tulips, hyacinths and ranunculus. Half the tulips we plant in one bed in the hoophouse, and half we plant outside for longer bloom time. The tulips planted in the hoophouse start blooming 2-4 weeks ahead of the field tulips, depending on how cool the Spring is. We get our ranunculus in a hoophouse mid

February and have to cover with remay – it's worth the effort, as the blooms come in earlier and better than if you wait – ranunculus do not like to get hot, which means first of June these days. We also started thinking about overwintering geraniums and other borderline perennials that we could start harvesting the first few month of the year.

2. By 2018 the demand for our flowers took off and we added two large florist accounts to our customer list. I also hired two employees who had experience growing flowers and making market bouquets, so we expanded into a market that was ready and eager to buy from us. We started adding retail to our previously skewed wholesale sales in the form of bouquet subscriptions, DIY buckets and Flower Share Memberships. Flower sales started gaining a larger percentage over greens sales. I made a decision I wanted to grow the business as a flower grower, not a flower farmer/designer, did not want to do weddings.

   We started getting tighter for space in the hoophouses for our Spring and Fall turnover. Added beds in the field for flowers and started putting out transplants earlier with hoops and remay. Flower sales are a lot more lucrative than greens – we can get more blooms per plants, there are a lot that are cut and come again, the variety of flowers keeps growing and we start focusing on adding perennials and ornamental shrubs to our repertoire. Greens sales are staying level but not expanding because we're focusing all our time on flowers. So the question becomes how do we grow more flowers, extend our season even more, where do we want to focus our expertise on?
   - More hoophouses?
   - Better use of the greenhouse? Could we start forcing bulbs in crates?
   - Grow more greens in the fields?
   - Analyze what kind of greens we're growing and if they are really worth the effort
   - Do we want to drop greens all together and get into wreath making, bulb forcing , designing, weddings, etc?
   - Do we start using mechanical means to prep beds, etc. or stay with no-till, labor intensive methods where we have more control over our product?
   - Do we maintain the organic certification for flowers or drop it? Keep for the greens? How do we juggle that?
   - Do we want to keep growing the over 75 varieties of flowers or start specializing in fewer but more in demand, like for wedding work, Valentines and Mother's Day, etc.

3. 2020 and Covid. The big question in March of 2020 was: What are people going to want/need more, food or flowers? All the florists are closed, weddings cancelled, events cancelled. The only markets open are the grocery stores. Will people want to spend money on flowers if they don't have jobs? I made the decision to go with our planting plan the way we had originally thought about it for 2020 and flower sales soared. The florists figured out how to get flowers to their customers, and we saw firsthand that truly "flowers feed the Soul". On top of customer demand, the supply chain for flowers through the wholesaler started falling apart, and locally grown flowers were suddenly the only ones available in many cases. That is still the case to a great extent today.
   - We started Online sales and pickup at the farm in 2020. Have an ardent following for our greens from local customers. Online green sales in the Spring are much stronger than those in the Fall.

- Covid made us evaluate what our markets are, where we are vulnerable, do we have all our eggs in one basket, what does our diversification look like in case of another market downturn?

4. 2022 and the future. Unity Farm has grown to the point of where we need to jump to the next level in sales, amount of product grown and if we want to use more mechanization in our production (labor costs). Some of our thoughts for the winter greens are as follows:
   - Our sales from greens have stayed the same for the past couple of years. We no longer have restaurant accounts and all of our sales are either to local grocery stores or from the online sales. We're seeing more competition from new farms in the area, and some of our markets are only taking a few types of greens, which makes it harder to create new markets from some of our standbys. We will need to devote some time to either revisiting our old restaurant accounts or developing new ones.
   - We are starting to see more pressure from insects and disease on the spinach and lettuce. We did not grow spinach at all in 2022 because the aphids had gotten so bad. Additionally, we had downy mildew on a couple of the varieties in 2021, which we've never seen before.
   - If I overwinter greens, I need to keep one employee on at least part time for most of the year. In the past, that employee and I are burnt out from working most of the year without a substantial break and start the new year out tired. Is it worth overwintering?
   - Since flowers bring in more money for the effort, would it be worthwhile to explore new possibilities such as wreath making, forced bulbs (tulips), forced bulbs in pots, overwintering flower transplants, shrub foliage for holidays, dried flowers and be able to drop the greens?
   - Is it worthwhile getting another hoophouse designated for the spring bulbs and overwintered flowers so we can maintain the existing three hoophouses for greens?

Managing Multiple Diseases in Cucurbits: Fungicide Update

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Managing diseases is an important component of a successful production program for cucurbit crops. At a minimum powdery mildew will occur. Several other diseases can occur in the northeast. Powdery mildew always occurs due to the quantity of easily wind-dispersed spores that the pathogen produces and the breadth of conditions under which it can develop (no high moisture requirement). The downy mildew pathogen also can move long distances; its occurrence in the northeast varies yearly, especially on crops other than cucumber. Occurrence of other diseases varies among farms depending on whether the pathogen is in the soil (several including Phytophthora blight), surviving in alternative host plants including weeds (e.g. white mold, viruses), present in insect vectors (e.g. bacterial wilt) or present in/on crop seed (e.g. bacterial leaf spot), and also crop susceptibility (cucumber is more often affected by downy mildew and bacterial wilt than other cucurbits but less often affected by powdery mildew due to excellent host resistance). Infected crop at a near-by farm can also be a source of pathogens that move short distances such as during a rainstorm (e.g. Plectosporium blight). Most diseases are more severe during a rainy than dry season because wet leaves or soil are favorable conditions for most pathogens (exceptions include powdery mildew, bacterial wilt, and virus diseases).

Fungicides are an important tool for managing diseases. Cultural practices, which include resistant varieties, are 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. Some targeted fungicides have narrow activity necessitating applying multiple products when more than one disease is occurring. This is especially true with the most common diseases, powdery mildew (caused by a fungus) and downy mildew and Phytophthora blight (caused by oomycetes).

Powdery mildew. An integrated program with both management tools (resistant varieties and fungicides) is recommended to maximize likelihood of effective control. The pathogen has demonstrated ability to evolve and become less effectively controlled by both tools. Resistant varieties are now available in most crop groups with new varieties released most years. Resistance in cucumber is standard in modern varieties and is so strong it is easy to forget this cucurbit type is susceptible until an Heirloom type is grown. Cantaloupe with resistance to pathogen races 1 and 2 have exhibited excellent suppression. Resistance in other cucurbit crop types is not adequate used alone (without fungicide applications) to prevent impact of powdery mildew on yield. Alternate among targeted, mobile fungicides in the 4 chemical groups below (first 2 most important), and apply with protectant fungicide to manage resistance development. Begin very

early in disease development (one older leaf out of 50 with symptoms). Fungicide efficacy and occurrence of pathogen resistant strains are studied every year at LIHREC.

Vivando or Prolivo (FRAC Group 50). Activity is limited to powdery mildew. They can be applied 3 times (4 for Prolivo at low label rate which is not recommended) with no more than 2 consecutive applications. REI is 12 and 4 hr, respectively. PHI is 0 days. Do not mix Vivando with horticultural oils. Less sensitive isolates have recently been detected.

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

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

Gatten (FRAC U13) was not as effective as Vivando when tested at LIHREC in 2018.

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

Resistance is a major issue. Recent testing of isolates from commercial crops in NY revealed a high percentage of isolates (67-100%) being resistant to Quintec from crops treated twice with Quintec even though a good fungicide program was used. Many isolates were also resistant to Torino (FRAC U6) and Endura (FRAC 7) although these or related fungicides were not applied. Almost all isolates tested were resistant to MBC fungicides (FRAC 1; Topsin M), although now in limited use, and QoI fungicides (FRAC 11; Quadris, Cabrio and Flint). Therefore, none of these are recommended. Occurrence of multi-fungicide resistant isolates is a concern.

There are several protectants for powdery mildew, including chlorothalonil, sulfur, copper, botanical and mineral oils, and several biopesticides. Sulfur is most effective.

Phytophthora blight. This destructive disease has more been severe recently in areas where there were intensive rainfall events, which created unusually favorable conditions. A key to successfully

managing this disease is managing soil moisture to avoid saturated conditions. Achieving this is difficult when rainfall amounts are large. Another key has been fungicides registered in recent years with targeted activity for pathogens in this biological group (Oomycetes). Information about these follows section on downy mildew. These are considered the reason many growers have been effectively managing Phytophthora blight. A preventive fungicide program is considered essential. Ineffective control with fungicides has been associated with poor application timing in some fields (application missed when rain began before expected) while in others favorability of environmental conditions seemed to have been too great. Development of fungicide resistance is a concern with all targeted fungicides due to single site mode of action; therefore, alternation amongst chemistry is recommended. Resistance to Ridomil, Ranman and Presidio have been detected in the US. Protectant fungicides, such as coppers, are not sufficiently effective to be recommended alone for Phytophthora blight; however, they are useful tank-mixed with targeted fungicides to manage resistance.

Biopesticides There are several products (including Actinovate, AVIV, Bio-Tam, Companion, Howler, Regalia, SoilGard, Stargus, TerraClean 5) that can be applied to soil pre-transplant, at planting, and via drip to manage the blight pathogen, *Phytophthora capsici*, in the root and crown zone and to induce resistance (Regalia). Most of these biopesticides can also be applied to foliage. They are approved for organic production. Some other biopesticides are labeled for *Phytophthora* species causing root rot.

Downy mildew is primarily managed with fungicides. Cucumbers with a new source of resistance are now available. Those that performed well in variety evaluations are an experimental from Tokita (others, CU201AS and CU203AS, are now available), DMR 401, NY264, Brickyard and Citadel, a pickling type suitable for fresh market. Some suppression, albeit variable, can be obtained with varieties bred to be resistant to pathogen strains present before 2004. Edisto 47, Planter's Jumbo, and Trifecta are resistant cantaloupe varieties. An integrated program with fungicides applied to resistant varieties is recommended, and needed with the resistant cantaloupes to achieve adequate control.

The forecast website for this disease at http://cdm.ipmpipe.org is an important tool for determining when fungicide application is warranted and to what crops. 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 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 two main clades. First clade to appear each year infects cucumber and cantaloupe. Second infects squash, pumpkin, and watermelon. Forecast system success depends on knowledge of where downy mildew is occurring; therefore, prompt reporting of outbreaks by growers to extension staff or the website is critical.

While the pathogen has potential to produce oospores, which would enable it to survive cold winters, pattern of disease occurrence in the US suggests this obligate (can't survive on dead plant tissue) pathogen is only surviving over winter where cucurbits are growing (e.g. south FL). Additionally, the two mating types are being found on different crop types. Oospores are produced as a result of sexual reproduction, which requires pathogen isolates of different mating type to grow together. If the situation changes and oospores are produced, downy mildew will begin developing in the northeast much earlier in the growing season. Plants are susceptible from the cotyledon stage.

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. With both diseases expect recommendations to change as pathogens develop resistance to additional chemistry and new fungicides become available. So far resistance has been associated with pathogen affecting cucumber and melon. Fungicides described below as being affected by resistance may still be effective for downy mildew in other types of cucurbits.

Fungicides for Phytophthora blight (PB) and/or downy mildew (DM):

Orondis (FRAC 49). The novel active ingredient, oxathiapiprolin, has exhibited excellent activity in fungicide evaluations. It is formulated with mandipropamid as Orondis Ultra (REI 4 hr; PHI 0 day) for both diseases, with chlorothalonil as Orondis Opti (REI 12 hr; PHI 0 day) for DM, and with mefenoxam as Orondis Gold applied once to soil at planting (REI is 0 or 48 hr depending on application method; PHI is 5 days) for PB. Either Orondis Gold or the formulations for foliar use are permitted used on a crop. Label use limits for other products are 33% of the applications when 3 or more applications are made or a maximum of 4 applications, whichever is fewer.

Elumin, Zing! and Gavel (FRAC 22). Zing! and Gavel are the only products that have a targeted fungicide and a protectant fungicide (chlorothalonil or mancozeb). All are labeled for DM; Elumin and Gavel are also labeled for PB. REI is 12 hr; 48 hr for Gavel. PHI is 2, 0 and 5 days, respectively. Apply no more than twice in succession. Total crop usage varies among products. 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 (FRAC 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.

Previcur Flex (FRAC 28). Activity is limited to DM. REI is 12 hr. PHI is 2 days. Label limit is 5 times in a season.

Phosphorous acid fungicides (FRAC P07, formerly 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 PB fungicides listed above.

Fungicides with documented or suspected resistance in the US. Resistance to Ridomil, Ranman, and Presidio was detected in the PB pathogen; most testing was in the southeastern US. Resistance to other fungicides was detected in the DM pathogen affecting cucumber including in the northeastern US. These are no longer recommended for DM in cucumber and melon (caused by pathogen Clade 2) and recommended used sparingly (less than label limit) for DM in squash and pumpkins (pathogen Clade 1) and used for PB early in the season when DM is not a concern. Resistance has been confirmed based on laboratory testing of isolates.

Ranman (FRAC 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.

Presidio (FRAC 43). Must be applied with another fungicide. REI is 12 hr. PHI is 2 day. Apply no more than 4 times in a season with no more than 2 consecutive applications.

Revus (40) and Zampro (FRAC 40, 45). 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) with no more than 2 consecutive applications (no consecutive 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 40 ingredient as Zampro.

Ariston, Curzate or Tanos (FRAC 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 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 aren't labeled for PB.

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.

Not 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.

Other diseases that can affect cucurbits and labeled fungicides.

Alternaria leaf spot. Fontelis (FRAC 7), Inspire Super (3,9), Aprovia Top (3,7), Miravis Prime (7,12), Pristine (7,11), QoI fungicides (11), Reason (11), Switch (9,12), Tanos (27), Omega (29).

Anthracnose. Aprovia Top (3,7), Inspire Super (3,9), Pristine (7,11), QoI fungicides (11), Tanos (27), Topguard (3,11), and Topsin M (1).

Bacterial leaf spot. Actigard (21) and copper (M1). Quintec applied for powdery mildew may apply some suppression of bacterial diseases.

Fusarium fruit and crown rot. Proline (3).

Gummy stem blight/Black rot. Fontelis (7)*, Aprovia Top (3,7), Inspire Super (3,9), Miravis Prime (7,12), Pristine (7,11)*, Proline (3), Rhyme (3), Switch (9,12), Omega (29), QoI fungicides (11)*, and Topsin M (1)*.

Plectosporium blight. Aprovia Top (3,7), Inspire Super (3,9), QoI fungicides (11), and Topguard (3,11).

* Resistance detected in the US.

See https://www.vegetables.cornell.edu/pest-management/disease-factsheets/ for additional information about diseases of cucurbits and management including fungicides, plus photographs.

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

Downy Mildew-Resistant Cucumbers for Fall Production

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Growing cucumbers through the late-summer and early fall is increasingly difficult. This is due to several factors including increasing pressure from insects and diseases which build up all season, but the main culprit is the disease known as cucurbit downy mildew (*Pseudoperonospora cubensis*). Cucurbit downy mildew (CDM) affects all cucurbit crops and can cause sudden and complete death of foliage, effectively ending crop growth. The pathogen is an obligate parasite, meaning it needs a living host to survive. Thus, the disease overwinters in FL where cucumbers are grown throughout the winter, and works its way north as the growing season progresses. There are several strains that affect different crops, but all strains affect cucumber, making them the most susceptible to CDM. The disease was controlled for decades with host resistance but in 2004 the pathogen evolved and overcame that resistance and now there is a great effort to breed new varieties with alternative sources of resistance. This is why growing fall cucumbers seems to have gotten so much harder in recent years, because it has!

Since 2016, the UMass Extension Vegetable Program has been conducting variety trials to evaluate new cultivars and breeding lines for their performance in New England in late-summer and fall, when downy mildew pressure is high. Over the years we have identified several new cucumber varieties with strong resistance to multiple diseases which would be good choices for fall production in the Northeast. Planting resistant varieties can increase profitability dramatically as they reduce or eliminate the need for fungicide applications, saving time and money! Organic growers should be especially quick to adopt this strategy since there are no effective fungicides to control downy mildew. All of these varieties are also resistant to powdery mildew, another disease that is expensive and time-consuming to control conventionally, and impossible to control with OMRI-approved fungicides alone. When I see susceptible varieties being planted after July 4th in southern New England I know they are doomed before they even begin flowering. Don't waste your time, money, and field or tunnel space by planting varieties like Marketmore76 in the fall! They *will* get disease and die early every year. Save those old favorites for the early season and use the list of varieties below for your later plantings. Thank you!

Methods. Each year we seed 8-10 varieties of cucumbers in the greenhouse during the first week of June and transplant into raised beds with **white** plastic around July 4th. We use white plastic because at this time of year we lose too many plants to transplant shock and heat-related death when we use black plastic. Plants are grown at 18" spacing with drip irrigation. We treat all plants with imidacloprid at transplant, irrigate about weekly unless there is rainfall, and fertigated with synthetic fertilizers twice—once at planting and again at vining. No other pest control is used, and we often still get serious cuke beetles and bacterial wilt by September. There

are 6-10 plants per plot and four replications of each variety in a randomized complete block design.

Downy mildew is usually first observed in the first or second week of August in Massachusetts, but this year (2022) we saw symptoms in our cuke trial on July 19th! Downy mildew pressure is always very high in these trials due to all the untreated and variously susceptible cucumbers in the study as well as in nearby CDM sentinel plots we use to monitor disease spread in different cucurbit crops. We rate disease severity (%) weekly and harvest twice a week. Fruit is marketable if it is of the correct size for the variety, is not misshapen, and does not have extensive cuke beetle, bird, or other physical injury. We take the weekly disease severity data and calculate the disease severity over the whole season (area under the disease progress curve, or AUDPC) using the following formula: $\sum^{n}_{i=1}[(R_{i+1} + R_i)/2]\,[t_{i+1} - t_i]$, where R = disease severity rating (% of leaf surface affected) at the *i*th observation, t_i = time (days) since the previous rating at the *i*th observation, and n = total number of observations). Values are calculated based on the average percent disease severity across the plot. Data are analyzed in SAS using a general linear model and means are separated using Tukey's HSD at alpha of 0.05.

Variety	Producer	Disease Resistance	Notes
TRI-CU234AS	Tokita	****	Slicer, smooth skin
TRI-CU236AS	Tokita	****	Slicer, smooth skin
CU231AS	Tokita	****	Slicer, smooth skin
NY264	Cornell/Commonwealth Seeds	****	Small pickler shape. Light green matte skin. Slow to produce and may not get the heat units needed to fruit in all of New England every year. Bushy, vigorous plants with no spines
DMR401	Cornell/Commonwealth Seeds	***	Slicer, OP
CWP21ACC	Commonwealth Seed	****	Pickler
Chaperon	Seminis	****	Pickler
Espirit	Seminis	***	Pickler
Citadel	Seminis	***	Pickler
Bristol	Seminis	***	Slicer
Brickyard	Seminis	***	Slicer
SVCS0025	Seminis	****	Slicer
Gateway (SV4212CL)	Seminis	***	Slicer
SV4142CL	Seminis	***	Slicer

Raceway	Seminis	***	Slicer

Table 1. This list comprises some of the better varieties we have evaluated over the years. We included varieties that had strong disease resistance (3 or 4 stars) and also produced good marketable yields. We have not evaluated every variety out there, we work with growers and seed companies to identify new breeding lines or cultivars with potential but can only fit so many in each year. Some of these varieties may disappear from the market, may not make it to market for other reasons, or may eventually be given a more user-friendly name :)

Reduced Tillage Cucurbit Production: Great Positive Effects on Soil Health, But What Are the Stumbling Blocks?

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Our goal is to produce high quality pumpkins/winter squash with high yields without wearing down our soil and depleting organic matter.

We plant into rye seeded the previous fall. We've found that one pass with our Unverferth Zone-Builder made when the rye is about 12" tall makes it much easier to prepare the planting zone to a suitable planting condition, with the final pass made just before planting.

Our production method is dependent on herbicides for weed control. Though we have recently had some success with rolling cultivators and knife weeders to manage in-row weeds, between the rows we rely on glyphosate applied either shortly before or shortly after planting. We then use pre-emergent herbicides banded over the zone.

The real stumbling block, as usual, is weed control. Because we are leaving so much organic matter on the surface, the options for cultivating are limited. Most traditional cultivating tools get quickly tangled with residual rye on the edge of the zones. Our recourse when too many weeds survive in the zone is to either back-pack spray with Round-Up or Gramoxone or to hand weed. We usually end up doing some of both of those.

Another major stumbling block is Round-Up resistant weeds. Specifically, Round-Up resistant Lambs Quarter. Additional herbicides are now sometimes required to deal with these.

Planting dates seem to have a lot of effect on the success of this method. This season (and I think it is a trend) the later planting dates performed the best with the least additional weeding passes. I think this is because the bulk of the weeds germinate after the soil warms and the delayed herbicides have more success killing the small emerged weeds.

With adequate weed control and successful prevention of Downey and Powdery Mildew, very high-quality squash can be produced.

Because the fruit sits on the rye straw, it is much cleaner and has far less trouble with soil borne diseases.

A primer on high tunnel cucumber production

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High tunnels, also called hoop houses, are a form of protected agriculture. The plastic-covered structure blocks rain, snow and strong wind that crops are exposed to when growing in the open field. High tunnels trap solar-generated heat that allow crops to be planted earlier and harvested longer. However, compared with greenhouses that are typically equipped with active heating and cooling and often supplemental lighting systems, high tunnels have a limited capability to maintain environmental conditions at the crop optimum range. Heating and cooling of high tunnel structures rely on passive measures: closing and opening of the sidewalls and/or gable vents. Thus, high tunnels are a more open environment compared to greenhouses, resulting in unique growing conditions.

Over the past 20 years, high tunnels have become increasingly popular as a season extension tool for small farmers. Seedless cucumber is one of the most popular crops grown in high tunnels. The climbing growth habit, parthenocarpic nature of setting fruit without pollination, high yield potential and long harvest window make seedless cucumber an ideal crop for high tunnel production.

A detailed guide published by the authors of this presentation, entitled High Tunnel Cucumber Production Guide, can be found at https://extension.entm.purdue.edu/publications/ID-521/ID-521-W.pdf. This guide provides resources and recommendations tailored to the distinctive growing environment of high tunnels. Recommendations are based on research efforts conducted in the Midwest U.S. and include cultivar selection, pruning and trellising systems, insect and mite pest management, disease management, plant physiological disorders and grafting techniques that are tailored to cucumber production in high tunnels.

Summer Cucurbits at Edgewater Farm

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Intro

Summer Cucurbits are an important part of our diverse crop mix here at Edgewater. Fresh cucumbers ,squash and zucchini are an early draw for our retail stand, wholesale offering, and to bulk out those leafy early season csa boxes. Melons and watermelons help draw mid and late season customers to the stand and the flavor of a locally produced vine ripened melon is incomparable. We grow between 5 to 7 acres of what we call summer cucurbits, yearly in many successions and with differing approaches. Today we will get into the basics as well as some of the nuances that we employ to get the job done.

Greenhouse management and Early season production

All the early sowings are started in a propagation house. tray type, sowings schedules and early nursery care is important to ensuring a good crop. To have early cukes, we have two heated high tunnels. Let's get into briefly covering management of these tunnels vs field system, shall we? I will talk about varieties, and how we try to map out our planting schedule based on demand for specific crops

Field Prep, Rotation, Nutrients.

Rotation is a major factor of soil health. In the spring we manage cover crop residue to prepare the field for planting. Many times we follow an intercropped cover of clover from a solanaceous crop and minimum tillage is required. Depending on weather and location we are able to flex and transition into the best site for the cucurbit crop. Being flexible is part of our planting strategy for all crops. Nutrients are applied based on soil sampling and crop requirements. Our field spacing is unique and would probably seem wasteful, but for harvest and for the multi year use of the intercrop it works for us.

(will explain the nitty gritty via slides here)

Planting

Once the transplants and the fields are ready, we pick a window when weather conditions look good. We plant with a water wheel transplanter, or seed by hand. Irrigation is all done by drip clear water. No fertigation, or chemigation because we are usually planting in multiple locations and at different times during the season. Early season transplants are hooped and covered with remay, giving us an early crop, but can also be a gamble depending on weather. Remay should help reduce early season striped cucumber beetle damage.

Cultivation

Upon removal of the remay, mechanical cultivation begins. We employ many tractor operated cultivators, hillside cultivators, lililston gang, knives, shovels, and half shovels, fingers, sweeps. We try and keep clean until plants run or we start to harvest. Sometimes hand weeding the edges is necessary if scheduled cultivation is missed or there are some good escapees, Felcos, machetes or hand hoes can manage this task.

Crop Care

Weekly scouting is done on the crop by the crew. If there are bad outbreaks of pests- cuke beetles, squash borers or deer- people are notified and assessment if action is necessary depends on the following: on how far along the crop is, what the threshold of acceptable damage is, will it affect upcoming successions.

For Fungal disease we read the reports from the colleges and the listserv as well as talk to other farmers to see what is coming and if disease seems imminent. We will get on a fungicide schedule. Preventative protection works for powdery mildew. Downy mildew is far harder to control as the conditions in our river valley seem to be perfect in the fall.

Harvest.

We have a harvest schedule every other day when the crop starts to fruit during the heat of the season. It moves to every third day when we get into september. Harvest is done by hand and trainers are picked to leave the less quality crop picked off the plants and left in the field, quality stuff goes back to the packshed and is cooled immediately.

Crop Cleanup

Upon completion of crop, we mow off all residue, then run a micro harrow over the biodegradable mulch. This aids us in drip tape removal as it cuts the vines, or weeds parallel to the tape, and it also preps the bed for a cover crop in the bed space. It also does not disturb the clover intercrop.

Growing Peaches in a Cold Climate

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Cold hardiness is one of the most important requirements for success in peach growing in New England. We measured it among 33 varieties grown as a variety trial in Concord, NH. Shoots were collected in Feb. 2021 and 2022, but significant bud death had occurred by the sampling date in 2022 following the severe Jan. freeze. Shoots were systematically exposed to temperatures as cold as -22 °F in a programmable chest freezer and were then examined for injury.

Redhaven remains one of the best varieties for flower bud hardiness. Other varieties with good hardiness in both years were Scarlet Rose and Messina (Table 1)**.** Most of the varieties had intermediate flower bud hardiness or were inconsistently hardy in the two years of testing. Varieties that were inconsistent showed good hardiness one year and less hardiness in the other. **Varieties consistently lacking flower bud hardiness were Brigantine, Galaxy, Jade, SilverGlo, and PF5D.**

Table 1. Flower bud hardiness rankings of 33 peach and nectarine cultivars grown in New Hampshire. Hardiness is based on controlled testing in 2021 and after a natural freeze in 2022.

Hardy	Inconsistently hardy	Intermediate	Inconsistently tender	Tender
Messina **Redhaven** Scarlet Rose	August Rose Avalon BuenOs Contender Cresthaven John Boy Manon Nectafest Saturn TangOs	Coralstar July Rose PF23 Selena SilverGem SugarGiant SugarMay White Lady	Desiree Emeraude Evelynn Glenglo PF17 PF9A-007	Brigantine Galaxy Jade PF5D Silverglo Spring Snow

Flower bud injury was measured in spring 2022 in a Springvale, ME orchard that had a sizable collection of new peach varieties. Bud survival comparisons in 12 varieties were consistent with the orchard in New Hampshire with some exceptions (Table 2). John Boy showed poor bud survival, and PF9A-007 showed greater hardiness in the Maine orchard.

Table 2. Flower bud hardiness rankings of 12 peach varieties grown in Springvale, ME. Hardiness is based on flower bud survival after a natural freeze in 2022.

Hardy	Intermediate	Tender
Coralstar Desiree Harrow Beauty PF9A-007 Starfire	Autumnstar Blushingstar Gloria PF15A TangOs	Emeraude John Boy

Orchard location and elevation can have an impact on flower bud survival and yield. This was evident in 2022 when bud survival was highly variable among orchards in Maine. Redhaven survival was 86% in Livermore and 0% at another nearby orchard. Elevation and air drainage were the primary differences between these two sites. The severely cold temperatures in January most likely occurred as an inversion where the coldest air settled at lower elevations. Orchards farther from the coast had better survival and yield when located at high elevations (>400 feet). Elevation was not as important in orchards near the coast where survival was generally good.

Flower bud survival can also depend on the degree of fruit thinning in the previous summer because a heavy crop load will stunt shoot growth and reduce the number flower buds for the coming season. As with apple trees, adequate fruit thinning is important for peach return bloom but also survival of cold winter temperatures. Having a greater abundance of flower buds can increase the chance that trees will have a crop of fruit following a cold winter.

Peach trees have a short life-expectancy that is most likely from winter injury in the shoots and limbs. Shoot hardiness was slightly greater than bud hardiness, and was variable among the 33 varieties (Table 3). Shoot hardiness rankings were similar to flower bud hardiness for most varieties.

Table 3. Shoot hardiness rankings of 33 peach and nectarine cultivars grown in New Hampshire. Hardiness is based on controlled testing in 2021 and after a natural freeze in 2022.

Hardy	Inconsistently hardy	Intermediate	Inconsistently tender	Tender
BuenOs Contender Cresthaven July Rose PF9A007 **Redhaven** Saturn Sugar Giant	Avalon Emeraude Glenglo John Boy Manon PF17 Silverglo TangOs White Lady	August Rose Brigantine Coralstar Sugar May	Evelynn Jade Nectafest PF5D Scarlet Rose	Galaxy Messina PF23 Selena Spring Snow

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Soil Moisture is Money in the Bank

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This document discusses the characteristics of soil moisture-based irrigation scheduling. It goes over the concepts needed to create an efficient irrigation regime with the goal of maximizing crop yield. Higher crop yield often translates to higher farm profits. Therefore, maintaining soil moisture at an adequate level with the goal of near-optimizing crop production can be "money in the bank."

Irrigation water management is the broader science behind irrigation scheduling and soil moisture monitoring. Irrigation water management is the act of timing and regulating irrigation water application in a way that will satisfy the water requirement of the crop without wasting water, energy, or plant nutrients or degrading the soil resource. This involves applying water according to crop needs in amounts that can be held in the soil and at rates consistent with the intake characteristics of the soil. Today, almost all irrigation water management plans are based on soil moisture monitoring, and the resulting irrigation scheduling is tailored to replenish soil moisture between pre-set parameters. Irrigation water management, irrigation scheduling, and soil moisture monitoring are implemented to keep soil available water at an adequate level. If soil available water is undersupplied, then plant growth will be limited even if all other factors are adequate.

Irrigation scheduling is the planning for soil moisture replenishment and is an important aspect of broader irrigation water management. An irrigation scheduling methodology helps determine how much water to apply and when to promote desired crop response and optimized use of available water supplies while enhancing soil, water, and air quality, yield, and profitability.

Soil water is lost as result of natural plant processes and is greatly influenced by the growth stage of the crop and the energy of the system during a determined period. The plant available soil moisture is strictly dependent on the water holding capacity of the soil and root depth. The soil water holding capacity is dependent on soil texture where; for instance, silty and loamy soils have greater water holding capacity than sandy soils. The plant available soil moisture is the range between soil field capacity and the soil permanent wilting point. Field capacity is a representation of the maximum amount of water in the soil that is available to plants. Permanent wilting point is the point at which plants can't effectively withdraw any more water from the soil.

Irrigation scheduling aims to keep soil available water close enough to field capacity for the plant to spend minimum effort in withdrawing soil water. To be able to keep the soil moisture close enough to field capacity we use a "safety" factor called Management Allowable Depletion (MAD), which is the amount that soil moisture is allowed to be depleted before triggering an irrigation event.

The USDA-NRCS recommends a management allowable depletion of 35% for vegetables, berries, and young orchards and of 50% for mature orchards and agronomic crops (like corn). To know the maximum allowable depletion (and in consequence the amount of soil water we want to replenish) per irrigation cycle we multiply soil available water capacity by the maximum allowable deception. This can be estimated or measured. For example, the USDA-NRCS estimates that the maximum available soil moisture content of sandy loam soils is between 1.6 and 1.8 inches of water per foot of soil, with 1.7 as an estimated typical value. In consequence, for vegetables, berries and young orchards the maximum allowable depletion of soil moisture is about 0.6 inches of water per foot of soil under root system (1.7 inches of water per foot of soil * 35% MAD = 0.6 inches of water per foot of soil). In this example, the irrigation scheduling regime will trigger irrigation events every time available soil moisture approaches 0.6 inches per foot under field capacity. The USDA- NRCS estimates field capacity for sandy loam soils to be about 2.5 inches of water per foot of soil, therefore, according to the previously calculated MAD, irrigation events should be set as soil moisture depletion approaches 1.9 inches of water per foot of soil.

Fortunately, soil moisture monitoring devices can directly or indirectly measure soil water, eliminating the need for estimates such as the previous example. Directly measured soil water is often expressed as a percentage and indirectly measured soil water is often expressed with units of pressure (such as Atmosphere (ATM), Centibars (cb) or Kilopascals (kPa)). When using soil moisture monitoring devices, the irrigation scheduling is still set based on the maximum allowable depletion from field capacity according to soil texture. For example, a direct measurement of soil moisture on a fine sandy loam soil may show field capacity at 20% soil moisture and permanent wilting point at 8%, leaving 12% of available soil moisture. Then for vegetable crops, irrigation should be set to happen when soil moisture approaches 16% (12% soil moisture * 35% MAD = 4.2% allowable depletion, then 20% field capacity – 4.2% depletion = 15.8% soil moisture for irrigation set point or about 16%).

In conclusion, understanding the concepts of field capacity, permanent wilting point, and management allowable depletion is key in the establishment of a soil moisture monitoring regime and irrigation schedule that supports maximum crop yield. Soil moisture monitoring devices provide the information necessary to implement an irrigation water management plan that determines and controls the rate, amount, and timing of irrigation water in a planned and efficient manner to minimize risk and increase yield often resulting on higher farm profits.

Greenhouse Monitoring: How To Beat The Odds

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If you ask a farmer if they've recently been to a casino, they'd probably say that they don't like to gamble. Considering that farming itself is quite a gamble, especially greenhouse growing, that's a little bit ironic, don't you think? I really do think!

Most farm operations are stretched pretty thin in the spring with a lot of money out before a lot of money comes in. It doesn't take much of an unexpected event to tip the financial balance to the disaster zone. Floods, high winds, cold snaps, man-made catastrophes like a car hitting a nearby utility pole at 2:30 am just as the bars close can have devastating impacts on agricultural operations, some to the point of bankruptcy. A few of those unexpected issues can be easily and affordably addressed and managed, however. Various types of monitoring systems can give you enough time to correct a potential tragedy, yet it is always surprising to me how farmers neglect that part of their business plan. We custom graft about 5000 tomato plants for area farms in February and March but I always try to do around 500 extra on speculation as I know there will be some growers who have a freeze out and need to replant. I shouldn't call it speculation as we've always sold those 500 plants for the past 10 years!

Walker Farm has 25 greenhouse/tunnel structures and various types of monitors have saved us at least once just about every year. The introduction of wireless monitors a while back made life during the cold spring nights a lot less stressful. We use a series of Wi-Fi monitors from the Monnit Company (https://www.monnit.com/). You'll need to have an Ethernet Gateway for about $240 and a subscription plan so you'll be able check out monitor readings in the cloud. Subscription rates vary depending on the number of monitors you use. We have the 25-sensor plan that costs $99 per year. Monnit has an app that will let you check out the temperatures and humidity of your greenhouses on your phone. In the old days I would do a walk-around to each heated greenhouse and feel the galvanized exhaust pipe from the heater to see if it was warm. Once we started installing high efficiency heaters that used pvc exhausts, I'd have to open each door and check the environment. Now, I can just pull up the app on my phone and check each greenhouse from the comfort of the living room chair. We have more sophisticated Wadsworth computer systems with alarm options in a few structures but we still like the Monnit and Thermalarm alerts best.

A Monnit temperature sensor sells for $83 and a sensor that also does a humidity reading costs $132. Both these units are coin cell powered (2032 type coin cell) and have a fairly good range. Each of these sensors show the remaining battery percentage, too. Monnit also sells a more powerful sensor and a range extender if you have some structures that might be beyond the reach of the smaller models. Since our propane company is not super reliable, we also use Monnit's propane tank sensors which can show fuel percentages on the phone app. You can check your system from anywhere with wi-fi or cellular service. Alerts can be sent to multiple contacts via text message, robocall or email.

Whenever possible we try to have a redundancy of systems, for example we have a large automatic lp generator but also a couple of backup gasoline units. For alarms, we like the Thermalarms which we have in every structure. They're daisy chained together with 18-gauge exterior thermostat wire. These alarms can be set for a high and low alert and are connected to an audible unit like a siren or electric doorbell. They sell for around $49 each and will operate during a power failure when hooked up with a battery system.

When we rented a greenhouse about 5 miles away for a while, we used a Sensaphone system. This unit requires a phone line and can also dial multiple contacts to make sure the alerts go through. It sells for $440 from Nolt's Greenhouse Supply. In fact, you can download the Nolt's 2023 Catalog for free from their website and check out more alarm systems on page 45. They list a solar powered alarm set for tunnels without access to electricity.

I always recommend the purchase of an alarm system before you buy a greenhouse or tunnel! You work too hard to lose all the effort you put into starting and growing crops due to one extreme event when the installation of a simple and affordable alarm system can help prevent most losses and keep your farm safe and profitable. Don't throw the dice on the weather, place your bet on a reputable alarm plan and you'll always come away with a win.

Simpler and More Powerful Record-Keeping: Airtable for Farms

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Thanks for attending this presentation! To access the tutorials mentioned in the presentation, visit the following links:

Airtable tutorials on YouTube:
https://www.youtube.com/@julian_post
Example databases on the Airtable Universe:
https://www.airtable.com/universe/creator/usrXDuXb0zfwTqU1C/julianpost

Strawberry Matted Row Renovation – Step by Step

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Strawberry bed renovation should begin as soon after harvest as possible. The earlier the beds get renovated, the more time new runner plants have to get established, resulting in larger crowns and more flower buds for next year. Early renovation also reduces weed pressure by tilling in many weeds before they go to seed, and it can help reduce insect, mite and foliar disease problems by interfering with pest life cycles at a critical stage of development. Before beginning the bed renovation process growers should evaluate the health of the beds and determine which should be carried over for another year and which should be plowed down and put into crop rotation. Beds that have a good plant stand, did not suffer winter injury, had good production, and have no major weed, insect or disease problems should be carried over for another year. Beds that do not meet these criteria should be plowed down and seeded to a suitable cover crop to eliminate weed, insect and disease problems that have developed, and to rebuild soil organic matter and health. Ideally, beds that are plowed down should be rotated out of strawberries for at least three years. If properly managed, crop rotation will greatly reduce pest problems and improve the vigor and longevity of strawberry beds without the need for soil fumigation.

Most organic strawberry growers using the matted row system have found that the beds should only be fruited one year then plowed down and put into rotation crops, rather than being renovated for a second harvest year. Trying to renovate a bed and carry it over a second year inevitably leads to major weed infestations and increased insect and disease pressure the next year, which can be difficult to bring under control for future crops.

Renovating a strawberry bed is basically a thinning process to promote healthy new growth that can support a good crop next spring. While some parts of the following renovation scheme may be modified for individual situations, all beds should undergo the following steps once harvest is complete.

1. **Broadleaf weed control**: If perennial broadleaf weeds such as dandelion, shepherd's purse, daisy or goldenrod are a problem and/or a high population of annual broadleaf weeds such as lambsquarters, sorrel or pigweed are present, hand-pull as many as possible, especially within the plant rows, and/or apply 2,4-D amine (Formula 40®), or clopyralid (Spur®).

2. **Leaf mowing**: Four to five days following the 2,4-D application (or immediately if 2,4-D was not applied) mow off the leaves of the strawberries about 1 ½ inches above the crowns. ***If the planting is weak or drought stressed, it is recommended that this step of the renovation process be skipped***.

3. **Fertilization**: Apply 40 to 60 pounds of actual nitrogen per acre (use the higher rate on sandy soils and fields where growth has been weak). Phosphorus and potassium applications should

be made according to soil test recommendations. Maintenance applications are generally in the 30 to 40 pound per acre range. Soil testing kits and information are available from your county Cooperative Extension office.

4. **Plant thinning/Tillage**: For the single matted row system, strawberry plant rows should not be any wider than 24 inches. After mowing off the leaves, till the sides of the rows to narrow the beds back to a width of 10 to 16 inches. Use the wider setting for varieties that tend to throw few runners or any fields experiencing drought stress. It is important to set the tiller so that it incorporates the mowed leaves to encourage their breakdown. This will reduce leaf disease and mite problems during the summer. The tilling should also spreads about one inch of soil up around the remaining crowns. Building the soil up around the crowns will increase drought tolerance, encourage new root growth and reduce winter injury.

5. **Subsoiling**: Soil compaction caused by tractor and picker traffic in the field can cause soil drainage problems and interfere with good root development. Using a subsoiling blade between the rows will break up compacted layers of soil and improve water infiltration. Subsoiling is best done late in the renovation sequence to prevent interference from straw and crop residues.

6. **Pre-emergent weed control**: To control annual weeds, apply terbacil (Sinbar® 80WP) according to label directions (2 to 6 oz. per acre). Be sure to follow all label precautions. ***To avoid plant injury, do not use terbacil if you do not intend to mow off the leaves***. Napropamide (Devrinol®) or DCPA (Dacthal®), or Satellite HydroCap® may be used as an alternative to terbacil at this time. If you are not using herbicides, regular cultivation, before weeds are more than 2" tall, will be needed throughout the summer.

7. **Irrigation**: To encourage rapid plant growth and get the most out of fertilizers and herbicides, irrigate the beds regularly. Strawberries will grow best if they receive 1 ½ inches of water per week during the growing season.

Don't forget your plants once these renovation steps are completed. Check the strawberry fields regularly during the summer for pest problems. Finding and managing problems early can prevent major problems next spring.

Growing Strawberries in Substrate

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Weather is one of the more challenging aspects to producing any crop. It is also one factor that growers have little, if any control over. Excessive rainfall, in addition to the physical impact of the moisture on fruit quality and marketability, can promote rapid disease development which will then further reduce yield and quality, or in some circumstances, can result in total crop loss. In Pennsylvania many tomato and raspberry growers have shifted to indoor culture to enable more consistent production of quality crops. An additional benefit to indoor culture is the reduced need for fungicide applications since the crop is not exposed to rainfall. Strawberries suffer from the same weather impacts as other crops but until recently were not economical to produce in protected culture. With the advent of better day-neutral varieties growers have started to experiment with growing strawberries indoors. The appearance of new diseases, such as *Neopestalotiopsis*, as well as the resurgence of *Phytophthora* and anthracnose (which are becoming more difficult to control) is putting additional pressure on strawberry growers to examine protected culture for their crops.

Indoor production can be done in the soil or in soilless media as well as in traditional greenhouses or in less expensive high tunnels. While the use of media is an additional expense, it helps overcome issues with soil-borne diseases and soil problems such as compaction, excessive salts and general poor quality. In addition, it allows the grower the potential to more closely control crop growth. Indoor culture of strawberries is a highly refined process in Europe but it is still a relatively new process in the US and there is much we still need to learn and adapt to our systems.

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

We have been conducting research in an attempt to better understand these systems ourselves and have looked at an evolving set of containerized production methods. The long-term goal is to develop a relatively low-cost grower-friendly set of recommendations that would be easily adoptable.

Research at Penn State on indoor strawberry production dates back to 2003-04. At the Rock Springs Research Farm (central PA) we looked at production of June-bearers and day-neutrals in a gutter system, but at that time, thought that the economics were not likely to result in

immediate adoption. Over the years, we trialed 13 varieties of day-neutrals and 8 June-bearers. June-bearers weren't productive enough over a long enough season to warrant the effort, and 'Albion' (a day-neutral) had the best combination of high yields and high quality. From 2015 through 2019 at Penn State's high tunnel facility, we compared grow-sleeves vs. grow-bags, incorporated fertilizer vs. soluble fertilizer, different media types, and different varieties of day-neutral strawberries in replicated trials.

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

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

Research shifted to the Southeast Research Center in Lancaster County (SE PA) in 2021. This part of the state is where many of our growers are located but has higher temperatures than in central PA. Day-neutrals are not supposed to be tolerant of hot conditions and expectations were that yields could be lower than at Rock Springs We wanted to test this before recommending any production system to growers.

We compared seven different types of growing media using the cultivar Albion. Six of these media were commercial mixes, as we heard from growers that having a pre-mixed media was greatly preferred over mixing their own due to time and labor needs. We used the same fertilizer source as we had at Rock Springs. The well water at Landisville was also high in pH and bicarbonates (but not quite as bad) with a pH of 7.5 and total alkalinity of 221 mg/L. The experiment started with no irrigation water acidification as we hoped we would be able to avoid doing this as we had at Rock Springs, but this did not work. The same fertilizer for high bicarbonate water was used but we found that when using media types that contained added lime (as in earlier experiments) the plants quickly developed symptoms of iron deficiency and tissue iron levels which were in the deficient range. Iron tissue levels in plants without symptoms, which were 30% higher, were still in the deficient range. Acidification of irrigation water started

in early September using sulfuric acid but iron deficiency symptoms never did improve and we were questioning our calculations. It turned-out that that the injector in our system was not functioning properly and was replaced this season (2022) – more on that below.

Despite these issues, yields were higher than expected (Table 1). The 2:1 peat:perlite mix didn't perform nearly as well in Lancaster as it did at Rock Springs, but the plants in this media still produced total yields of 1.4 pounds per plant. The best performing media was BC-5++ from BVB Substrates in the Netherlands. Total yield from plants in this media averaged 2.1 pounds per plant, with a mean berry weight of 13.9 g/berry (a large berry). This media, as was the case with the peat:perlite mix, seemed to have a good combination of high porosity and water-holding capacity. It was different from the rest in that it had peat chunks that were lumpy and somewhat spongy and you couldn't compress the media even if you tried to. The peat in this mix is referred to as "white peat", which was a new term to us, and is listed on the bag as "slightly decomposed raised bog peat". Yield from the other commercial mixes, despite varying degrees of iron deficiency, were intermediate and all quite similar to each other, varying between 1.61 to 1.77 pounds per plant. Marketable fruit percentage was lower than anticipated due to misshapen fruit, most likely from tarnished plant bug early in the season, and 'soft spots' from spotted wing drosophila (SWD) from mid-August on.

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

We repeated our media trial in Lancaster again in 2022 but with some modifications. We did not use the BC-5++ from BVB as this media was not available here in the US (we had some shipped in from Canada for 2021) and shipping costs were very high for the small amount needed. Our focus was still on easily available mixes and we used three mixes commonly used by growers. In addition, we used two fertilizers (Plant Marvel 20-7-20 as last year) and Plant Marvel 18-6-18 which provided more than twice as much iron in EDTA and DPTA forms, and nearly 3 times as much zinc. In addition, we 'lightened' the BK 25 by adding 20% by volume either rice hulls or perlite to see if this improved growth. Irrigation water was again not acidified at the start of the trial as we wanted to see if the fertilizers alone could provide adequate pH adjustment. The trial was started one month later than in 2021 but by early August (about the same time as last year) we again noticed chlorosis on the plants and began acidification. Unfortunately, pour through monitoring showed that we were not achieving the fertility levels and pH reduction needed. After numerous system adjustments we replaced the injector and the problem disappeared. Valuable lesson learned to check the actual injector output and dilution rate rather than relying on EC alone! Fruit and runners were stripped from the plants to try for one late flush of fruit to see if media differences were observed. Data through September 19, 2022 are presented in Table 2.

Yields are lower than last season because of later planting, high pH and insufficient fertility but all medias seem to be performing similarly except the EPM 40 treatments. Berry size is smaller than last season, but marketable percentages are similar.

What we learned from these experiments was that 1) media that is well-aerated and well-drained is best; 2) we may need to find a media that doesn't have added lime, especially in high

bicarbonate water situations, as this compounds problems with iron deficiencies; 3) we likely need to acidify the water source and fertilizer solution from the start of the growing season in high bicarbonate water situations, though whether we absolutely would need to do this if we had a media without added lime is still a nagging question and 4) there probably are some different combinations of media types, fertilizers and acidification options that would work well together for most situations, but there probably won't be a one-size-fits all solution.

Table 1. Media type and strawberry yield information for the study conducted at the Penn State Research Center in Lancaster County from June 4 to November 22, 2021.

Media	**Marketable Yield/Plant (lb)**	**Total Yield/Plant (lb.)**	**Mean Berry Weight (g)**	**% Marketable***
2:1 Peat:Perlite	0.98	1.44	13.6	68.1
BVB Substrates BC 5++	1.38	2.10	13.9	65.4
Berger BM 5	1.05	1.61	13.6	65.3
Berger BM 6	1.14	1.69	14.4	67.3
Frey's Mix 400	1.10	1.69	14.4	65.5
Pro Mix BK 25	1.21	1.77	14.3	67.7
Pro Mix BX	1.12	1.73	14.0	64.5

*Low percentage marketable fruit was largely due to early season tarnished plant bug damage and late-season SWD presence.

Table 2. Media type and strawberry yield information for the study conducted at the Penn State Research Center in Lancaster County from July 6 through September 19, 2022.

Media	**Marketable Yield/Plant (lb)**	**Total Yield/Plant (lb.)**	**Mean Berry Weight (g)**	**% Marketable***
Pro Mix BK 25 (20)	0.49	0.72	12.9	67.9
Pro Mix BK 25 (18)	0.54	0.75	11.4	73.1
Lambert EPM 40 (20)	0.24	0.41	11.8	58.5
Lambert EPM 40 (18)	0.40	0.55	11.5	72.0
BK 25 RH** (20)	0.47	0.62	11.6	75.6
BK 25 RH** (18)	0.50	0.62	11.5	79.0
BK 25 CP*** (20)	0.45	0.67	12.2	67.4

*Low percentage marketable fruit was largely due to late-season SWD presence.
**Rice hulls at 20% by volume
*** Coarse perlite at 20% by volume

For comparison (10 plants vs. 28-30):

BC 5 ++	0.46	0.68	11.7	67.3

Strawberry Anthracnose Issues

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Strawberry anthracnose is a major disease of many crops worldwide and can affect many aboveground parts (fruit, crown, leaves, petioles, and runners) of the strawberry.

Using improved molecular techniques, it is now known that there are several species causing anthracnose fruit and/or crown rot in strawberries. These species primarily belong to one of two species complexes (or clades) - the *Colletotrichum acutatum* complex, and the *C. gloeosporioides* complex. Based on work conducted at the University of Maryland by Dr. Mengjun Hu, *C. nymphaeae* within the *C. acutatum* complex has been found to be the main species causing anthracnose fruit rot in the Mid-Atlantic region (as in California and Florida). *C. fioriniae*, one of the species that causes bitter rot in apples and anthracnose ripe rot in blueberries, was isolated from fruit lesions too, but less frequently than *C. nymphaeae*, which was also isolated from strawberry plant runners, leaf petioles, and strawberry crowns.

Anthracnose has been a documented problem in strawberries off and on, mainly in warm regions of the country, since the 1930's. Recently, however, many growers in other regions have shifted to using the plasticulture production system. The varieties used in this system, developed for growing in cool and/or dry climates (California, France), have considerable susceptibility to anthracnose. This coupled with the hot, wet conditions encountered in the Southeast and Mid-Atlantic has resulted in more frequent disease incidences. This also resulted in greater usage of category 11 fungicides for anthracnose management at a time when there were very few materials with efficacy against this disease.

Anthracnose is a warm-weather disease, and the warm microclimate on black plastic mulch and under row covers is conducive to sporulation. Further, anthracnose spores are readily spread by splashing water and the presence of plastic, rather than a straw mulch, allows dispersal of the spores to nearby plants. Combine these factors with susceptible varieties and disease resistance to certain fungicides, and you certainly have a recipe for disaster.

So where does anthracnose come from? Anthracnose spores can survive in the field for up to 12 months under dry conditions and in strawberry crowns for up to 3 years. The disease can survive on weed species in a field but how did those weeds become infected in the first place? It is generally accepted that anthracnose is most often spread through infected transplants. Growers in the south were advised to source plants from northern nurseries after a 1980's anthracnose epidemic there because anthracnose was not common in cooler locations. Unfortunately, to meet grower demand for plug plants, plant materials (mother plants, runner tips, and plugs) are often obtained from multiple sources and some plants are shipped to several locations before arriving on the grower's farm. The result is more opportunities for plant material to be exposed to several disease sources. Fungicide-resistant anthracnose strains are likely spread this way as well.

What should you do to minimize your losses from anthracnose? Plant resistant strawberry varieties whenever possible within your production system. Ask your nursery plant suppliers about their planting stock sources. Plug plants that originated from tissue-cultured stock likely spent time in a greenhouse instead of the field and stayed on the same farm for their entire production cycle are therefore much less likely to have picked up diseases. Minimize rain splash by mulching with straw, use high enough plant populations to fill the beds, or use a low tunnel or high tunnel to again reduce splash. Practice good sanitation – clean equipment, worker's hands and work clean fields first. Minimize weed pressure. And consider resistance management in your fungicide program. The table below was developed to both manage resistance concerns for gray mold as well as anthracnose in a field. Note that the choice of fungicides depends upon time of the season (and thus main disease of concern) as well as resistance management issues. FRAC group 11 fungicides may or may not be effective against anthracnose depending on the strains present. The best anthracnose management program will include both cultural controls as well as carefully selected fungicide applications.

Table 1. A visual representation of what a recommended fungicide program that integrates gray mold and anthracnose control would look like through the season.

Early Bloom →	→	Late Bloom →	Green Fruit →	Early Harvest →	→	Late Harvest
Maintain continuous coverage with thiram (group M3) or captan (group M4)*						
thiram or captan	thiram or captan	thiram or captan	thiram or captan	captan	captan	captan
*If in matted row production and gray mold is the major concern, utilize thiram more and captan less. If in plasticulture and when growing anthracnose-susceptible varieties, captan may be needed to a greater extent.						
If weather is wet, add one of the following single-site fungicides to the above, making not more than 2 applications of any activity group over the season.						

Primarily for early season gray mold control		*Save for use during harvest*
- Fontelis, group 7, or		*For gray mold and anthracnose fruit rot:*
- Kenja, group 7, or		- Switch, group 9 + 12, or
- Luna Tranquility, group 7 + 9, or		- Miravis Prime, group 7 + 12, or
- Merivon Xemium, group 7 + 11**, or		- Luna Flex, group 7 + 3
- Luna Sensation, group 7 + 11**		
**While these products can be used for gray mold, their use will increase selection pressure for anthracnose resistance to group 11 materials.		*For gray mold but not anthracnose fruit rot:*
		- Ph-D or OSO, group 19
		For anthracnose fruit rot but not gray mold:
Alternatives to group 7 fungicides if needed:		- Tilt, group 3, or
- Rovral, group 2 (pre-bloom only)***, or		- Inspire Super, group 3 + 9, or
- Elevate, group 17***		- Cabrio, group 11***, or
		- Pristine, group 7 + 11***, or
		- Quadris Top, group 11 + 3***, or
		- Quilt Xcel, group 3 + 11***
***May be used once per season if resistance to active ingredients in these products is known to be low on your farm. Do not, however, make more than 2 applications of any activity group over the course of a season.		

Table source: Hu, M., and K. Demchak. 2022. Strategies for effective management of botrytis and anthracnose fruit rot in strawberries. https://extension.psu.edu/strategies-for-effective-management-of-botrytis-and-anthracnose-fruit-rot-in-strawberries

Managing Nitrogen in Organic Systems

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Organic farmers supply nutrients to growing plants from a variety of sources: compost, animal manures, soil organic matter, cover crops, and an ever-increasing variety of purchased supplements such as blood meal, soy meal, alfalfa meal, and blended combinations of these and other materials. All of them must go through biological decomposition to release nutrients in a plant-available form. Because of its biological nature, release rates are highly dependent on the complexity of the organic form, soil temperature, and to some extent soil moisture. Nitrogen fertility is especially difficult to manage. Weather-dependent release rates and multiple loss pathways cause varying complications in nitrogen management from year to year. A number of studies have been conducted on natural/organic N sources, to document their conversion (mineralization) rates to nitrate, the primary form of plant-available nitrogen (PAN).

Most long-season crop plants take in the bulk of their total seasonal N requirement relatively early in the growth cycle. There is some crop to crop variability, but generally nitrogen uptake increases dramatically starting 3 – 4 weeks after planting. This concentrated uptake period will last for another 3 - 4 weeks, corresponding to the period of rapid height and foliar growth. It is imperative that there be an ample supply of PAN during this 4 week uptake "window".

A number of studies looking at N mineralization from natural fertilizers have been conducted over the past 10 – 20 years in MI, CA, OR, VT, ME, and recently in GA. For example, in 2013 a nitrogen mineralization study was conducted at the University of Maine using a wide variety of locally-available natural N fertilizers. A field-moist soil was blended with feather meal, blood meal, soy meal, alfalfa meal, fish meal, corn gluten, pelleted broiler manure, and a variety of blended natural fertilizers from North Country Organics, NatureSafe, Bradfield Organics, and Espoma. These were compared to 2 chemical N sources: urea and ammonium sulfate. All materials were mixed with soil to supply 100 ppm total N (200 lb/A equivalent) and incubated at 15 C (60 F) for 16 weeks. Plant available NO_3-N was measured at 1, 2, 4, 8, 12, and 16 weeks, to document N release rates for a growing season time frame at the cooler soil temperatures common in the Northeast (Figure 1).

Chemical sources released the majority of PAN in only 2 – 3 weeks. The early release of PAN from chemical sources, prior to crop uptake demand, leaves PAN much more susceptible to major losses from heavy rainfall events. By contrast, N release from natural sources reached maximum release at 4 – 8 weeks, better matching the crop uptake window for N. The majority of natural materials in this study had nearly identical release rates to blood meal, including feather and soy - traditionally considered to be slow release materials (Figure 1).

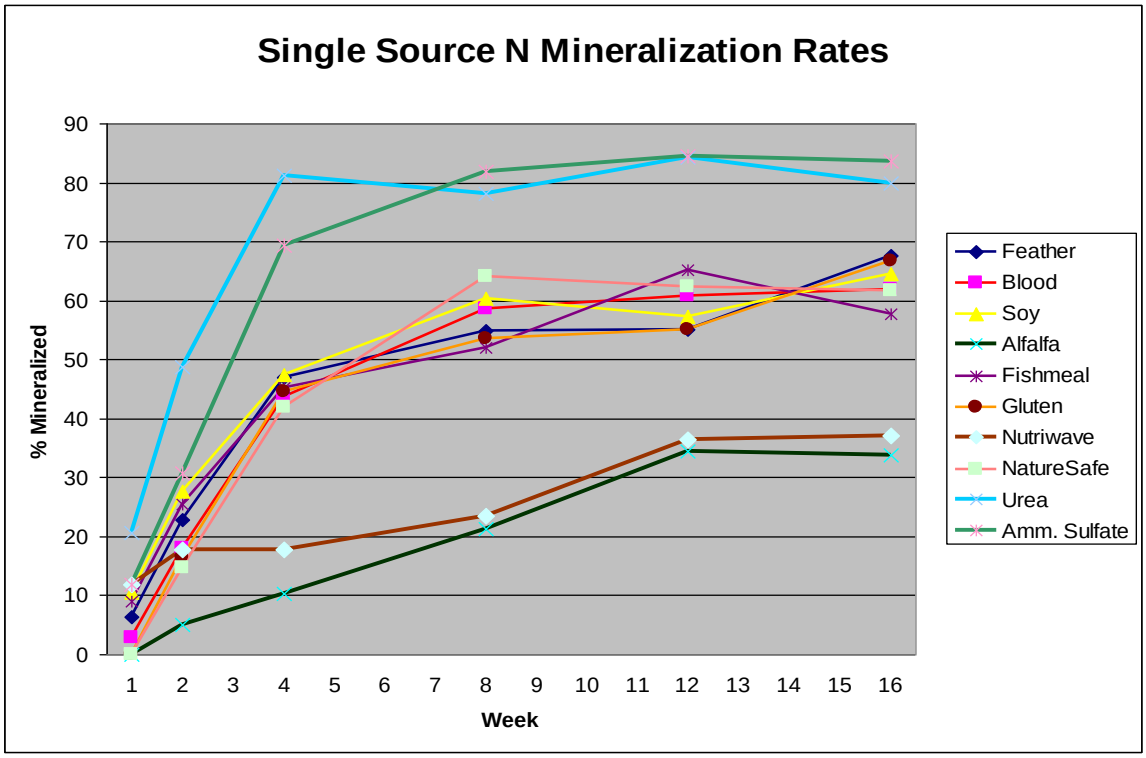

Figure 1. Nitrogen mineralization rates at 60 F soil temp. University of Maine, 2013.

Broiler manure and alfalfa meal exhibited a much slower N release rate than other single source materials. This can be attributed to the higher Carbon to Nitrogen (C:N) ratio of these materials. This effect was also documented in other studies. In all studies, materials with a C:N ratio below 10:1 released relatively rapidly while those above 10:1 released more slowly. This was documented as early as 1942 in a study at Rutgers University. C:N ratio information is not listed on the labels of commercially available plant and animal meals. However, if they contain more than 5 % Nitrogen content, they should automatically have a C:N ratio < 10:1 and will be a relatively fast release nitrogen source. Blended fertilizers in the ME study exhibited N release rates that were initially rapid and more gradual later on, since they contain a variety of N sources meant to provide some rapid release and some slow release nitrogen.

N release from common materials used in ME, MI, OR, CA, GA.and NJ studies were all in general agreement. However, ME release rates in 8 weeks at 60 F were matched by the OR study in only 4 weeks at 72 F. In effect OR doubled ME N-mineralization rates by increasing soil temp by 12 F (7 C). This illustrates the effect of soil temperature on N release from non-chemical sources. N release in warmer soil, later in the season, will be much more rapid than in cool soil in spring. Likewise, N release will be more rapid in high tunnel production, with higher soil temperature, than in open field production.

N release from manures is also biologically mediated and is also affected by C:N ratio and soil temperature. Many manure sources have a significant portion of the total N content already partially mineralized in the ammonium form, with the remainder being organic N. The ammonium-N will be converted to nitrate relatively quickly, often within 2 weeks, and is considered to be immediately available. N release from the remaining organic fraction will be

more gradual, generally about 50 % mineralized in 4 – 8 weeks depending on soil temp and C:N ratio. There is a well documented N release from manure the second and even third year after application, though at a much diminished rate. Manure organic N release rates are from 25 – 55 % the first year, 10 – 12 % the second year, and 4 – 5 % the third year.

N in cover crops (green manures) is almost exclusively in the organic form. Crop residues release nitrogen generally between 2 - 6 weeks after incorporation. However, this will be delayed with higher C:N residue or at lower soil temperatures. Legume cover crops have a higher N content and a lower C:N ratio and will generally release more PAN and more rapidly than non-legume cover crops.

Compost and soil organic matter have already been partially broken down and so release PAN at a much reduced rate, regardless of C:N ratio. In a compost incubation study at UMaine in 2013, 4 sources of compost were mixed with soil to supply 320 ppm total N (640 lb/A) and incubated at 68 F (20C) for 8 weeks. From all 4 sources, a maximum of only 6 % of the organic N content was fully mineralized to PAN in 8 weeks (Figure 2). Two of the sources (composted under cover) had a substantial portion of total N in plant available form at the start of the incubation, but even these released only an additional 5 % of the organic N during incubation. The GA study also showed very low mineralization rates of organic N from compost. Some unfinished compost sources in that study actually immobilized nitrogen. Compost is a very slow release source of PAN, though there can be a continued release in the subsequent 1-2 years after application.

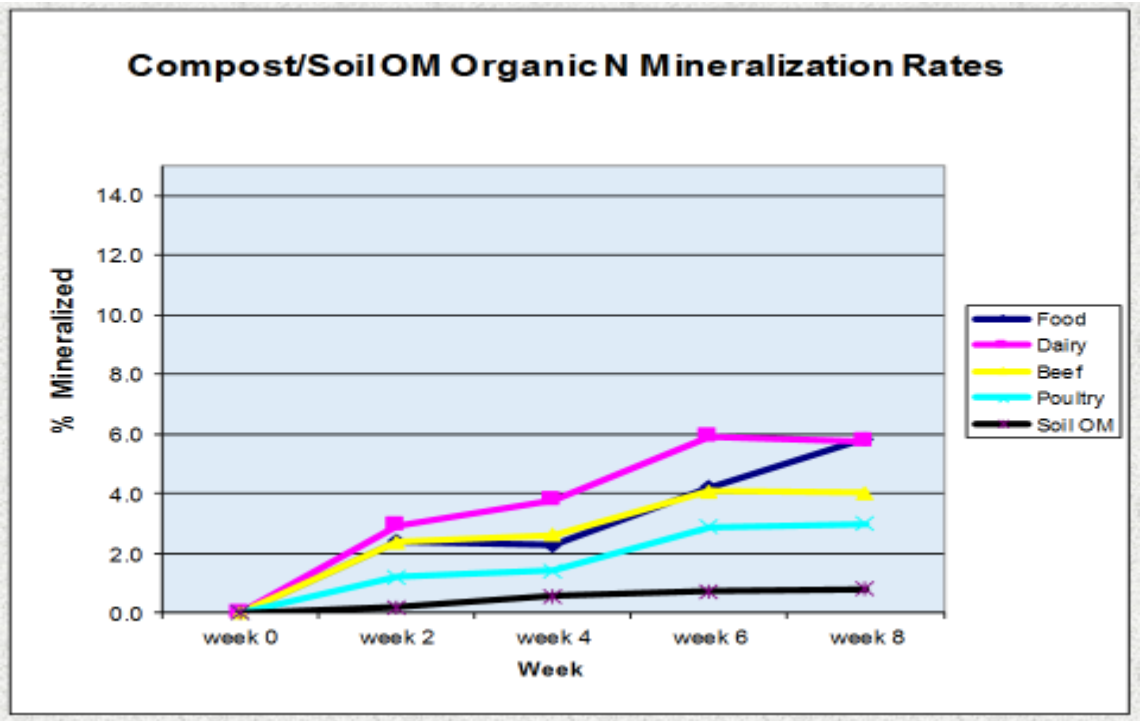

Figure 2. Compost mineralization rates at 68 F soil temp. University of Maine, 2013.

Get the best from biopesticides

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The active ingredients in biopesticides include microorganisms (microbes), plant extracts, and naturally-occurring chemicals (like potassium bicarbonate). As a result, some of the ways they control pests (their modes of action or MOAs) are different from conventional, synthetic chemical pesticides. Also, many of them have several MOAs, and not all MOAs apply to all pests listed on the label. If a biopesticide contains live microbes, and especially if its MOA requires the microbes to stay alive on the plant for some period of time after application, this also has important implications for how the product is stored and applied. Understanding the mode of action of a product will help you get the most out of it.

Eat - live microbe grows on/in pest
Biopesticides with this MOA can work against insect pests (e.g., products that contain *Beauveria bassiana*) or plant diseases (e.g. Contans, which contains *Paraconionthyrium minitans* strain CON/M/91-08). Biopesticides with this MOA that I am aware of contain fungal spores. These spores will germinate once they land on the insect or disease-causing pathogen, and may have temperature and/or humidity requirements for germination. Make sure you store the product correctly, confirm compatibility with other products before tank mixing or applying, and apply under recommended environmental conditions.

Poison - biopesticide (or its products) kills the pest directly
Biopesticides with this MOA can work against insect pests (like products containing *Bacillus thuringiensis*) or diseases (e.g., Double Nickel containing *Bacillus amyloliquefacies* strain D747, or products containing potassium bicarbonate). Obviously, potassium bicarbonate products do not contain live microbes. Some biopesticides that poison pests do have live microbes that continue to produce antimicrobial products after they are applied. Others work because of the compounds the microbes produced while the biopesticide was being made.

Keep out - live microbe grows on plant, leaving no room for pests
Biopesticides with this MOA can work against plant disease (e.g., Actinovate which contains *Streptomyces lydicus* WYEC 108, or Serifel, which contains *Bacillus amyloliquefaciens* strain MBI 600) and may be bacteria or fungi. The microbes in biopesticides with this MOA must be alive when applied and need to be able to grow on the part of the plant that is being protected.

Turn on resistance - turns on the plant's defenses before pest attacks
As far as I know, these biopesticides only work against plant diseases, but as new products are developed, or as we learn more about existing biopesticides, this may change. Some examples include Regalia (giant knotweed extract) and Lifeguard WG (*Bacillus mycoides* isolate J). Some

of these products contain live microbes that need to stay alive (like LifeGard), while others do not. These biopesticides need to be applied before infection.

Grow strong plants– makes plant stronger, healthier, more resilient
As far as I know, these biopesticides only work against plant diseases, but as new products are developed, or as we learn more about existing biopesticides, this may change. Some examples include: Serenade (*Bacillus subtilis* strain QST 713), RootShield (*Trichoderma harzianum*), and Sil-Matrix (potassium silicate). Some of these products contain live microbes that need to stay alive, while others do not (e.g., Sil-Matrix). These biopesticides need to be applied before infection.

Repel - pest avoids plants treated with biopesticide
Biopesticides with this MOA can work against insect pests, but perhaps only on certain insect life stages. Some products with this MOA could contain live microbes, while others do not. You can evaluate the effectiveness of products with this MOA, not by scouting for dead insects, but by looking for reduced damage or lower insect populations on treated plants. Examples include: Grandevo WDG (*Chromobacterium subtsugae* strain PRAA4-1 and its spent fermentation products) and products containing azadirachtin,.

Stop feeding - stops pest from feeding; pest eventually starves
Biopesticides with this MOA can work against insect pests either by contact or ingestion and may only be effective against insects of certain ages or life stages. It depends on the biopesticide and pest. Examples include insect-killing viruses and some types of *Bacillus thuringiensis* products. Some products with this MOA could contain live microbes, while others do not. Live pests will still be present for some time after applying a product that works in this way, since the pests die of starvation. Watch for feeding damage to stop or a reduction in insect numbers over time to know if the product is working.

Stop growth - stops pest from growing or molting; pest eventually dies
Biopesticides with this MOA may work against insect pests either by contact or ingestion and may only be effective against pests of certain ages or life stage. It depends on the biopesticide and pest. Examples include Venerate (*Burkholderia* spp. strain A396) and products containing azadirachtin. Some products with this MOA could contain live microbes, while others do not. Products with this MOA will not kill pests immediately, but will prevent them from growing or molting. Watch for insect populations to decline over time, but do not expect pests to die immediately.

Stop reproduction - hampers pests' ability to find a mate or produce eggs
The two main groups of biopesticides I know of with this MOA are (1) pheromones that make it hard for male and female insects to find each other, or (2) products that reduce the number of eggs female insects lay. Grandevo (*Chromobacterium subtsugae* strain PRAA4-1 and spent fermentation products) is an example of the later, but may not work in this way against all ages and species of pests listed on the label. The products I know of with this MOA do not contain live microbes. This mode of action will reduce insect populations in subsequent generations, not the current one. So use it on a pest with multiple generations per season, or in combination with other MOAs.

If the biopesticide contains live microbes, make sure you…

- store the biopesticide correctly (and for the correct amount of time); check the label.
- confirm compatibility of the biopesticide with other products before tank mixing or applying; read the label and contact the manufacturer with questions.

In addition, if the biopesticide contains microbes that need to stay alive for some period of time after application in order to be effective, make sure you also…

- pay special attention to the recommended optimal environmental conditions for application; start by reading the label.

Remember!

- Biopesticides are pesticides. Their labels are the law. Read the labels and follow them, along with other pesticide application laws in your state.
- Not all biopesticides are permitted for use in certified organic production. Check with your certifier if you have questions.

Questions to ask when you are considering/purchasing a biopesticide

The manufacturer or dealer should be able to tell you:

- How does it work (MOA)?
- Is it alive? Does it need to stay alive to work?
- Special instructions for storage or use? (e.g., temperature, spray tank pH, time of day)
- Is it compatible (in the tank, greenhouse, or field) with other products in use (e.g., pesticides, fertilizers)?

Biopesticide Resources

- Find more information on how to use biocontrol (including biopesticides): go.nysipm.org/biocontrol-tools
- Results from efficacy trials on Long Island for biopesticides and organic fungicides: blogs.cornell.edu/livegpath/research/organic-disease-management/
- Cornell organic vegetable resources (including efficacy results): cals.cornell.edu/discover/agriculture/organic/vegetables

Beyond Bok Choy: Growing and Marketing Asian Vegetables

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There is a wide array of specialty Asian vegetables that can provide growers with a large untapped local market. Growers that are in areas with Asian populations not serviced by culturally appropriate supermarkets may find a new customer base and revenue streams. Growing higher quality produce may also provide a market differentiator from other farms within the region who are growing Asian produce using methods designed for yield and not taste. This talk will focus on varieties of produce not typically available and seen at market, as well as tips on how to grow standard varieties for higher quality.

Bok Choy - Typically seen on many market farms as well as larger operations, bok choy is the Asian vegetable most familiar to people. Varieties such as Win-Win, Joi, and Bopak are common. Many growers grow these to 3LB+ size heads. **We cannot recommend enough that growers stop doing this.** Large bok choy heads lose their sweetness, become overly watery, and are difficult to cook. Asian markets do not value large bok choy, but are receptive to baby and mini variety types. These can be sold as bagged greens similar to salad mix. Harvesting them is similar to other cut greens, and their dense heads add significant weight. Transportation to market is easier than large heads. These can be marketed as easier to cook and sweeter, as well as carrying a higher price than the large heads. Varieties suitable are marketed as 'shanghai' type, and extra-dwarf varieties exist as well. Varieties bred for mini production have a more elegant appearance and deeper vase shape. Flea beetles cause significant damage to marketability, insect netting can prevent damage, though use of row cover into the early summer may encourage bolting. Your standard brassica spray regimen will also deter pests.

Chinese Cabbage - High yielding and productive cabbage. Napa can be grown similar to most western cabbage varieties, and has high production value in spring and fall. Spring cabbage should be seeded and planted relatively early to achieve high yields before the heat of summer comes on, though danger of premature bolting occurs when exposed to long periods of sub 50 degree nights (we have never seen this happen, for what it's worth). Michihili types are tall and narrow, while napa types are barrel shaped and wide. Kimchi producers typically buy large amounts of napa type throughout the year, though comparable pricing is competitive on the commodity market. Purple cabbage varieties provide market differentiation and higher price points, and are eye catching on the market stand. Typically, these are more similar to tall michihili types than the barrel shapes of napa cabbage. These varieties are subject to higher variation, rogue types that grow like mustards or produce green heads, and are difficult to grow in the spring. We find that a variety like Scarlette has a high uniformity in head formation, with less than 5% of off types in the field. Yield per plant is smaller than napa types, typically 2-3LB, whereas napa can average 5-7LB per plant. Aphid damage can cause shrunken, deformed heads with low yields. Non-systemic spraying is difficult to accomplish for aphid damage, IPM and biological controls are more useful if that is the case. Marketability is not so much an issue with

flea beetles as some of the outside layers are stripped, though leads to lower yields if unmanaged. Looper damage causes significant crop loss as they can burrow deep into the heads, management and spraying is necessary, though some processors will accept cabbage with the sections cut off if you're desperate.

Yu Choy Sum - Yu Choy Sum is a tender brassica suitable for bunching or bagged baby cuts. Similar to broccoli raab, it is sweet with a tender stem. Plants are direct seeded with no need for thinning, though aiming for a plant every .5-1". Choy sum can be cut at any point during stalk formation and full maturity occurs when it sends a flower head up. Once the bud opens its quality begins to degrade, and the stalk will also hollow. We recommend beginning harvesting as the stalk reaches one to two inches in height, as the harvest window is very small once it achieves bud formation. Time your harvests so you can finish your succession as the buds form, or succession plant so that you can harvest budded choy sum and then move onto another round. Many purveyors and buyers will not purchase choy sum when flowering. Thin, reedy stems are considered inferior quality and occur if temperatures are too hot during its maturing period. Like choy sum, flea beetles will affect its marketability, and aphid prone growers will find them congregating in the flower bud. We grow choy sum in 5 rows on a 40in bed top, and typically achieve .75 to 1LB per row foot.

Ponytail / Chonggak Radish - A specialized type of radish used for making kimchi. It has a distinctive shape with a flattened end reminiscent of the double knots of the shape of Korean boys' hair during their coming of age ceremony. The greens are not separated from the roots when sold - they remain connected when made into kimchi. This is a high value crop in Korean markets and has high potential for specialty sales. Pick when 4-5 inches long and the flattened bottom has developed. Note that the greens are the prized part of this radish so it is not suitable as a storage crop.

Bitter Melon: Bitter melon is a vining cucurbit vegetable that is eaten throughout many cultures, including East Asian, South Asian, and Caribbean. It is known by a variety of names such as kerala, ampalaya, balsam pear, and caraili. Size and appearance of this vegetable vary by variety, but they are generally elongated fruits similar to cucumbers, but with tapered ends, and very bumpy. They have a short shelf life after harvest of approximately one week. They are prized for their intense bitter flavor and health value. Leaves are eaten in some cultures as well and can be dried down for tea. Seeds have a hard coat and require a 24 hour soak before planting, but once field planted, they only require trellising to thrive. Despite being a cucurbit, they are not affected by cucumber beetles or other pests, and in our time growing them they have not been susceptible to disease. The plants must be trellised and we recommend using a metal trellising system as the rapid onset of leafy growth and vines may not be supported by hortnova type netting.

Resources:

You can find seeds for Asian diaspora crops at:

Kitazawa Seed Co. (www.kitazawaseed.com)
Second Generation Seeds (www.secondgenerationseeds.com)

TrueLove Seeds (www.trueloveseeds.com)

If your customers are the type who like recipes and further culinary insight, we have found the following websites to be excellent starting points:

Woks of Life (Chinese) (www.thewoksoflife.com)
Omnivore's Cookbook (Chinese) (www.omnivorescookbook.com)
Hungry Huy (Vietnamese) (www.hungryhuy.com)
Hot Thai Kitchen (Thai) (ww.hot-thai-kitchen.com)
Just One Cookbook (Japanese) (www.justonecookbook.com)
Maangchi (Korean) (www.maangchi.com)

Asparagus Production at Fairwinds Farm

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Fairwinds Farm is a 130-acre small fruit and vegetable farm located in the towns of Topsham and Bowdoinham, Maine. We grow asparagus, mixed vegetables, strawberries, raspberries, high bush blueberries, sweet corn, popcorn, dried beans, grain corn and wheat. We grind the grains in our own mill for cornmeal and flour. We also have a sugarbush of about 2000 taps.

Today we will be talking about our asparagus production.

Why we grow asparagus: Asparagus fits well into our cashflow scheme; it gives us income in the early part of the farmers' market season, leading us into strawberries. It is a high-value crop that has high demand in both the retail and wholesale markets. We grow six acres of asparagus. They were planted in two-acre blocks over a six-year period, with our first planting made in 2012. Due to the long-term nature of asparagus, we only grow it on land which we own…we do not plant it on leased land.

How we grow asparagus: We start prepping the site the year before planting. We submit soil samples and apply amendments based on the test results. The correct PH is very important when growing asparagus. We aim for a ph of at least 7.0
Another aspect of field prep is to eradicate weeds; we do this by the use of cultural techniques, such as repeated discing, and by using appropriate herbicides. **Keeping weeds out of asparagus is Very Important!**

The Planting Year: We generally plant the crowns in early to mid-May. We plant approximately 8,000 crowns/acre. We dig trenches that are 12" deep and are spaced 5' apart. We apply lime and P & K in the trenches according to our soil tests, and lightly incorporate it. We space the crowns at 12", then lightly cover them. We use a waterwheel transplanter, without water or the wheel, for our crew to ride on while laying out the crowns. We can plant two acres in a morning. We keep covering the crowns throughout the season, as the ferns grow (leaving part of the fern exposed).

Weed control is very important, and very difficult, during the first year. We control weeds with lots of cultivation, hand weeding and use of a Reigi Weeder. We got behind on the weed control after planting our second 2-acre plot…and found ourselves pulling lambs quarter in the fall that was taller than us. That taught us the importance of not getting behind on weed control during the planting year! In accordance with the Fruit and Vegetable Growers Guide, we apply appropriate grass control. We also keep the crowns irrigated during the first year, if needed.

We monitor the plants, and spray for Japanese and/or asparagus beetles, again, based on recommendations in the Vegetable Guide. We also scout for disease and spray, if needed, per the guide.

After a killing frost, we mow the ferns to ground level; cultivate the aisles and add lime if needed.

Year two and successive years: In early spring (as soon as the ground is thawed) we apply herbicides according to the guide (based on the type of weeds we had in the field the year before). We generally will start to see spears poking out of the ground in late April.

We begin to harvest when the spears are 13 – 14" long. We have harvest by snapping the spears at ground level with our hands. Harvesting this way, as opposed to using a knife, allows for both hands to be snapping spears, as opposed to one grasping the spear and the other holding the knife. This makes harvesting quicker, and eliminates potential injury with a knife.

Over the years we have gone from walking and crawling while harvesting; to pulling crew members in sleds behind a tractor while they harvest; to using a home-made wheel frame pulled by a tractor that held three people harvesting three rows at a time; to our current piece of equipment that we purchased used in 2022…a four-row self-propelled harvester which allows us to harvest six acres in the course of a morning.

We harvest the spears into bins (with all spears facing the same direction), which are then taken to our wash station and sprayed down to remove field heat. Then we use an assembly line set up to process as the spears for selling. We have three stations set up for sorting and trimming the spears. We trim them to 12" …then they are put into bundles of 1 lb. and banded with standard purple PLU asparagus rubber bands. We have a banding machine which simplifies and expedites the banding process…and eliminates the breakage of spears by trying to put the bands on by hand. The bundles are dipped into a tank of fresh cold water; then into a tank of cold water with Sanidate. We pack the 1 lb. bundles into 1-1/9 size wax boxes with the bottom of the box lined with an asparagus pad. We pack 24 bundles (lbs.) per box.

We harvest 5-6 days per week, depending on growth. When the temperatures are high, we will harvest everyday (you could actually harvest twice in one day, if conditions are hot and dry). When temps are cooler, we may go 2 – 3 days between harvests. Our harvest season generally lasts 5 – 6 weeks; until we start harvesting strawberries.

We sell the majority of our asparagus direct to consumer at our farmstand and farmers' markets. The rest is sold wholesale to restaurants, local stores, other farms and distributors.

The demand for our asparagus is high…we could sell even more if we grew more.

In 2022, our wholesale price was $120/ case of 24 lbs. ($5/lb.). Our retail price was $7/lb. Our average yield is approximately 5000 lbs. Retail is about 90% of our sales.

Renovation: After our asparagus harvest season we do the following:

Mow the ferns to ground level.
Spray with Gramoxone to kill the weeds.

Apply fertilizer and lime according to our soil test results from the previous fall. (We typically only apply fertilizer at renovation.)
Cultivate the aisles to work in the plant debris.
Apply herbicides based on recommendations in the Fruit and Veg. Guide.

Again, it is important to keep weeds out of the asparagus, as weeds can quickly take over the field.

In August, we may apply additional herbicides, if needed. Every year we seem to have different problem weeds. In the past, our biggest problems have been lambs quarters, plantain and grass.

In October, we collect and submit soil samples from each of our two-acre plots.

After a killing frost, when the ferns are brown and flopped over, we mow them to ground level and leave the residue.

Artichoke Cultivar Performance in Maine

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Globe artichokes (*Cynara cardunculus* var. *scolymus*) are native to the Mediterranean region, which continues to dominate production globally. Monterey County, California produces the vast majority of US grown artichokes. However, pockets of commercial artichoke production are developing in Texas and other regions. In Maine and New England artichokes can be found on farm stands and in backyard gardens.

Artichokes are perennial plants and members of the Asteraceae family, which also includes lettuce, thistles, chicories, and sunflowers. They are not reliably winter hardy in Maine and are grown as annual from seed. In order to produce buds in their first year, artichoke seedlings must undergo vernalization (exposure to cold temperatures). The harvestable component of artichokes are buds that, if left unharvested, will mature into vibrant purple inflorescences. Properly vernalized plants commonly produce 10-20 buds per plant, and occasionally more than this. However, only several buds per plants will be "primary" buds, which typically are large enough in diameter to market individually. Buds that form at plant axials further down on the plant are "secondary" buds, are edible but smaller in size. The smaller buds comprise the majority of buds that a plant produces.

Seedling Production

In 2021, five globe artichoke cultivars were grown at University of Maine's Highmoor Farm, Monmouth, ME. Cultivars included Colorado Star, Green Globe Improved, Imperial Star, Tavor, and Wonder. Artichokes were seeded March 22. Two or three seeds were placed into 50-cell trays filled with Coast of Maine Bar Harbor Blend media. Trays were maintained on heated mats at 75-80 ˚F until seeds germinated, and then mat temperature was lowered to 65-70 ˚F. Trays were moved off heating mats 3 weeks after seeding.

Artichokes vary in their chill requirements, with most cultivars need exposure to 250 – 500 hours below 50 ˚F. The recommended vernalization process for annual production involves exposing 4-6 leaf seedings (approximately 6-8 weeks old) to an environment that is 45-50 ˚F for at least 10 days. Many growers and researchers simply transplanting artichokes early in the spring relying on sufficiently cool temperatures to meet the chill requirements. While in many cases this can be successful, the process of vernalizing plants in coolers is not labor- or space-intensive, and has the greatest chance of uniformly meeting chill requirements.

In this experiment, seedling trays were placed into a 40 ˚F walk-in cooler on May 10, for 14 days prior to transplanting. Seedlings were thoroughly watered before vernalization, and afterward were watered with Peter's 20-20-20 (1 Tbsp per gallon), water soluble fertilizer.

Table 1.Characteristics of artichoke cultivars evaluated during 2021 at University of Maine, Highmoor Farm.

Cultivar	Bud Color	Days to harvest	Annual Production	Organic Seed Available	F1 / OP	Spines
Colorado Star	purple	75	Yes	No	OP	Very
Green Globe Improved	green	75	No	No	OP	Yes
Imperial Star	green	85	Yes	Yes	OP	Yes
Tavor	green	88	No	Yes	F1	No
Wonder	green w/purple base	90	Yes	Yes	OP	Few

Bed Preparation and Transplanting

Beds were prepared three days before transplanting by spreading 500 lb per acre of 10-10-10 fertilizer ahead of rototilling and forming raised beds with a single drip line. Three mulch systems were evaluated: straw mulch, black plastic, and bare ground. We hypothesized that a straw mulch may mediate hot summer soil temperatures and reduce weed pressure. Black plastic would suppress weeds but elevated soil temperatures might effect yield. The bare ground treatment would not produce warm soil but would have increased weed pressure.

The trial was transplanted on May 24 in a split-plot design, using mulch as the main plots and cultivar as the subplots, with four replicated blocks. Therefore, each block had one bed of each mulch treatment, and five varieties subplots. Plots consisted of 12 plants; with end plants was used as a guard. Data were collected from the center ten plants of each plot. Seedlings were transplanted using a jab transplanter into single rows at 24” in-row spacings. Transplants were watered transplants with Nutriculture Soluble Fertilizer (12-45-10) at a rate of 3 lb per 50 gallons water. Straw mulch was applied June 15.

Growing Conditions

The 2021 growing season can be characterized as changeable. The spring and early summer were warm and dry, while the fall was warm and wet. July was unusually wet and cool, and August more typical for this region.

Table 2. Recorded monthly weather data during the 2021 growing season.

	May	Jun	Jul	Aug	Sep	Oct
Total rainfall (inches)	1.67	0.70	6.62	1.12	6.14	4.19
Avg daily temperature (°F)	56	69	66	72	64	54
Max daily temperature (°F)	92	94	87	92	81	79
Min daily temperature (°F)	35	46	50	52	46	37

Observed Pests and Diseases

Several pests negatively impacted artichoke production. Aphids, primarily green peach aphid, fed on lower leaves, likely slowing growth early in the season. Additionally, thrips caused twisting and curling of leaves and to a lesser extent, damaged some buds. Tarnished plant bug was observed later in the season. Applications of Assana XL were made on, July 23, August 8, and September 8. Gray mold (*Botrytis cinerea*) was the only identified pathogen in this trial, and caused only a minimal loss of buds.

Harvest

Artichoke harvest began August 20 and were made weekly until September 17. A final harvest was made October 1. To assess whether artichokes were ready for harvest (ie, fully sized), buds were squeezed to assess how densely packed the bracts were. Buds were harvested by clipping with 2-3" of stem using hand pruners. Buds were sorted into USDA size classes: 48s (3-3.5"), 36s (3.5-4"), 24s (4-4.5") and 18s (>4.5"). Buds smaller than 48s were categorized as "very small". Plants continued to produce high-quality buds (mostly secondaries) with some frost injury, dark spots on bracts, through light frosts until a hard freeze killed the plants.

Results

Transplant survival

The number of living plants in each plot two weeks after transplanting was recorded. Bare ground had the greatest plant survival followed by straw mulch and plastic mulched plots (Figure 3). The differences were not statistically significant. However, there was an 11.5% decrease in plant survival observed on black plastic mulch compared to bare ground. Temperatures were very high at the time of transplanting, and plant loss is thought to be related to heat stress. Transplanting under cooler conditions and irrigation are recommended for mitigating heat stress.

Vernalization

Success of vernalization was measured as the number of plants producing buds in each plot. Marketable buds were produced on 55% to 77% of plants, with no statistical differences between cultivars in the proportion of plants that produced buds. This indicates that the chilling requirement may not have been fully met for each of the cultivars. Or, that some seedlings of each cultivar were not at the proper developmental stage to respond to the vernalization treatment.

Marketable Yield

Yield data are shown below as both the number and weight of buds. Buds under 3" in diameter could be sold either way, and are suitably sized for quart containers (or similar), depending on one's market. Any buds that fit into USDA size classes could likely be sold individually. These size classes are summed in the table below and are categorized as "large".

Green Globe Improved produced a greater number of very small and total buds than any other cultivar in this trial. Imperial Star and Tavor were mid-level performers, both of which we found to be more attractive than Green Globe Improved (see next section for descriptions).

Artichokes on black plastic produced more small and total marketable buds by weight than plants in the straw mulch. Those on bare ground also outperformed straw plots for total marketable

weight. While soil temperatures in the straw mulch treatment were moderated by the straw (data not shown), the mulch itself became a weed issue. Clearing weeds from under the straw mat was difficult and often ineffective. We suspect that this weed pressure caused a decline in yields relative to bare ground and plastic mulch treatments.

Table 3. Average Artichoke yield at Highmoor Farm, Monmouth ME in 2021.

	Average Marketable Buds per Plant[z]					
	Very Small (<3")		**Large (3 to > 4.5")**		**All Marketable**	
	Number	**Weight (g)**	**Number**	**Weight (g)**	**Number**	**Weight (g)**
Cultivar						
Colorado Star	4.96 b	305 ab	0.82	172	5.79 b	478
Green Globe Improved	8.84 a	451 a	0.57	108	9.41 a	559
Imperial Star	5.54 b	304 ab	0.77	157	6.31 b	460
Tavor	5.82 b	338 ab	0.71	146	6.54 b	484
Wonder	5.35 b	284 b	0.51	98	5.87 b	381
Mulch						
Bare Ground	6.50	360 ab	0.87	176	7.37	535 a
Plastic	7.12	411 a	0.72	141	7.83	552 a
Straw	4.70	238 b	0.45	92	5.15	330 b

[z]Values in a column that are followed by the same letter are not different.

Small versus Large Bud Production

The proportion of total buds that were large enough to be marketed individually (> 3" diameter) was not statistically different across mulches or varieties.

Table 4. Artichokes larger than three inches in diameter for cultivars grown on different mulches.

	% Buds > 3" Diameter		
Cultivar	**Bare Ground**	**Plastic**	**Straw**
Colorado Star	36.6	34.4	34.6
Green Globe Improved	18.8	24.8	13.5
Imperial Star	37.5	32.5	50.2
Tavor	39.3	17.2	49.5
Wonder	38.0	18.9	18.0

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Celery Production for Profit

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Pleasant Valley Farm is located in a valley in a rural town 25 miles northeast of Saratoga Springs, New York and we have been operating it as a small family organic fruit and vegetable farm since 1988. We own 60 acres and rent our neighbor's 120-acre farm; we use a total of about 4 acres for vegetable production, 1/2 acre for large fruits and 1/4 acre for small fruits, and keep another 3 acres in cover crops for rotation. We grow a diverse selection of more than 40 types of vegetables and fruits with organic methods (certified through Certified Naturally Grown www.naturallygrown.org) for retail sales year-round through an online store and part-time at one local farmers' market, and a small amount is sold to several local restaurants and businesses.

Our focus has always been on season extension and through many years of trial and error, as well as working with other farmers, we have had great success in growing celery almost year-round as a very profitable crop.

JANUARY: Seed celery in the Greenhouse directly into 128 cell trays early January. Varieties: Kelvin and Tango. Kelvin gets really tall. Transplant into our high tunnels in March. Spacing: 3 rows on 3' bed 12" apart. (some do 10")
Production can start in late April or early May if there is some minimal heat, but with our tunnel and basically no heat, production starts mid-May to late May. We pick when outside stalks are big enough to harvest and we only peel off outside celery branches, so these same plants produce all season. We bunch and sell at $3 to $4 per bunch with .5 to .8# per bunch, depending on season and size of stalks.

Production of this celery will continue all year until approximately December or early January. Minimal heat on very cold nights.

JULY: Late in July, seed celery and transplant up as it grows. We grow it on our radiant heated benches in the Greenhouse all winter. When they are 8-10" tall and in quart-sized pots, we start taking off the outside branches to form small bunches. Sold for $2.50 per bunch. Production starts approximately in late January and continues all spring, usually until the tunnel celery is ready. Potting up as necessary.

PESTS:
Aphids-We use M-Pede. Dunking the pots in the GH is best. ……. Once or twice eliminates them.
GH soil fungus gnats in GH: using beneficial nematodes weekly all winter/spring in the GH keeps them under control. (From Arbico)
Tunnel rarely has any issues except the virus on some plants, especially when the celery is planted on the outside bed.

Fertility: 120# of Nitrogen pre-plant in tunnels. All other nutrients are in optimum range on the soil tests and feeding every week starting a month after transplant through drip with Nitrogen and potassium is important and also very important the Boron is at optimal level.
GH: Bi-weekly fertility with Stress-X and Chilean through Dosatron.

Economics: Production is amazing with the celery and much of what we have learned can be credited to Mike Palulis at Echo Creek. In 2022, his one bed 88'x3' produced 1300# of celery May 1 to Sept 1. It would have produced more but was ripped out for winter production. His retail value was over $7800 and hence that small space extrapolated out to almost $1 million per acre!! Our celery produces until the end of December depending on the weather, then we cut the whole thing before the weather takes a huge dive into low teens and it stores to sell in our root cellar for 3-5 weeks easily. We have 3 row covers over it in the late fall on cold nights and will run minimal heat a few nights to save it if necessary.

Yearly production benefits us as well as our customers. It's a great, profitable crop!

Preemergence Herbicides for Tree Fruit Production

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Weeds compete with fruit trees for light, nutrients, and water. These competitive interactions are especially problematic during the orchard establishment and the flowering and early fruit set stages of crop development. Larger weeds can grow into the canopy and interfere with the deposition of crop protection chemicals and harvest operations. Weeds that flower at the same time as apple bloom can draw pollinators away from the crop. Dense weed coverage can provide habitat for populations of vertebrate and invertebrate pests and alter microclimates which may influence disease development. Vining species that grow into the scaffold can weaken or damage branches. Some weed species, like poison ivy (*Toxicodendron radicans*), can be directly injurious to orchard laborers.

Across all commodities in the US, herbicides are the most used tool for managing unwanted vegetation. This includes in the weed-free strip that occurs under tree fruit canopies. When weeds are present, foliar postemergence herbicides are needed to reduce their cover. Because postemergence herbicides are applied to standing plants, treatments must be made in a timely fashion to small and succulent weeds to ensure good coverage and to reduce the potential for environmental stress to reduce herbicide performance. The first is especially important with the contact herbicides (like Gramoxone (paraquat)) are only active against treated foliage. The second is especially important for systemic (i.e. translocated herbicides), like Roundup (glyphosate), which may see reduced activity when plant growth is slowed down by conditions that don't favor active plant growth and development. Resistance to many postemergence herbicides is also a significant concern. In New York, glyphosate resistance is already widespread in horseweed/marestail (*Erigeron (Conyza) canadensis*) populations, but two cases of paraquat resistance have recently been identified in fruit systems where the active ingredient was extensively used (Maloney and Sosnoskie, Summer 2022. https://nyshs.org/fruit-quarterly/).

Bare soil also offers an opportunity to engage in weed suppression – through the application of residual preemergence herbicides. Contrary to the belief of some, preemergence herbicides do not have any effect on weed seeds; they are not soil sterilants. Instead, preemergence herbicides prevent germinated weed seedlings from becoming established. This is accomplished through the inhibition of seedling root growth, seedling shoot growth, or both. These herbicides must contact the soil and then be activated, usually via rainfall. For example, the Alion (indaziflam) herbicide label states "*Weed control activity may be reduced if the application is made to soil covered in heavy crop or weed debris that prevents a uniform distribution of the product reaching the soil.*" Always check the label to determine optimum surface conditions for each product although clean and smooth surfaces that are free of cracks are often ideal.

Preemergence herbicides can persist in the soil for varying lengths of time to prevent weed emergence and establishment; many can last for two to three months, but some there are some that are significantly shorter and some that can provide extended control throughout the growing

season. The length of time that soil-applied herbicides can/will remain active is influence by multiple factors: soil conditions, climatic conditions, chemical properties of the herbicide, and the interactions between the three considerations. Soil factors include composition/texture, organic matter content, pH, and organic matter (which can affect how tightly or loosely the active ingredient is held/bound) and microbial activity (which impact the degradation process. Environmental factors include soil moisture content and temperature, which can influence chemical and biological degradation rates. Sunlight can also affect herbicide persistence by breaking down materials that are not incorporated (i.e. photodegradation). An example of a photo-sensitive herbicide class would be the dinitroanilines (WSSA Group 3). The chemical composition of an herbicide affects a chemical's persistence by influencing its solubility (which can influence leaching potential) and volatility.

Soil conditions must be a consideration when choosing which residual herbicides to use, but weed spectrum, application timing, and crop age are also crucial factors. Like postemergence herbicides, soil-applied products vary with respect to their weed control spectrums. Active ingredients should be selected based on the common and troublesome weeds present at a site, with recognition that tank mixes or sequential applications of multiple products may be necessary to achieve thorough suppression. Thought must also be given to the presence of herbicide resistant weed species; for example, when dealing with glyphosate-resistant horseweed/marestail, the use of residual herbicides may be needed to reduce the numbers of established plants that must be treated postemergence. The timing of herbicide application is also influenced by the biology and ecology of weed community members. Because residual herbicides are mostly ineffective against emerged plants (although, some can provide burndown activity on small seedlings, such as diuron or oxyfluorfen containing products), treatments must be applied in advance of weed seed germination. This would be in the fall to target winter annuals and in late winter or early spring for summer annuals. Some products, like Alion, are extremely persistent and under some conditions may be effective at suppressing both types of weeds. Crop species and tree age will also drive herbicide selection. Not all herbicides are labeled for use in all fruit trees nor on both bearing and non-bearing acres. Always review labels to ensure a safe and legal application. All herbicides should be directed to the base of the trees to maximize weed coverage while minimizing trunk contact. Even soil-applied chemistries can cause damage if they contact green bark, foliage, flowers, or fruit. Applications to soil with cracks can facilitate root exposure to herbicides.

The following are some general notes about pre-emergence herbicide use:

- Preemergence herbicide incorporation and efficacy can be affected by the presence of leaves and standing vegetation and a clean spray surface improves control potential for many products.

- With very few exceptions, perennials (except germinating seedlings) are not likely to be impacted by preemergence herbicides.

- Tank mixes may be necessary to increase the spectrum of weed control; some products may have some postemergence activity but should not be relied on to control standing vegetation.

- Tree age restrictions vary among herbicides, some products allowed year of planting, other products some products can only be used in older stands. Not all herbicides are registered for use in all tree crops.

- Preemergence herbicides can injure crops, not just from root damage but also from contact with foliage or stem tissue.

- Pay attention to incorporation/activation requirements.

- Herbicide use rates can be dependent on weed species present, soil type, organic matter content, and tree age

- Herbicides can have limits on the numbers of sprays, the separation of sprays (sequential application timings), or the amounts of product applied per year.

- The longevity of preemergence herbicide efficacy can be affected by use rate, herbicide chemistry, soil type, organic matter, soil microbial community composition and activity, and environmental factors that facilitate breakdown.

- Herbicide resistance can develop for residual products. Rotate herbicide modes of action as is possible and use alternate control strategies when appropriate for weed suppression.

Perennial Weeds in Tree Fruit Production

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Weeds compete with fruit trees for light, nutrients, and water. These competitive interactions are especially problematic during the orchard establishment and the flowering and early fruit set stages of crop development. Larger weeds can grow into the canopy and interfere with the deposition of crop protection chemicals and harvest operations. Weeds that flower at the same time as apple bloom can draw pollinators away from the crop. Dense weed coverage can provide habitat for populations of vertebrate and invertebrate pests and alter microclimates which may influence disease development. Vining species that grow into the scaffold can weaken or damage branches.

Perennial weeds can be particularly difficult to manage in tree fruit systems. These plants are defined as being able to live for more than two years. Their survival over time is due to their extensive root systems or other underground storage structures (i.e. bulbs, tubers, and rhizomes) that store energy and facilitate regrowth. The Weed Science Society of America regularly surveys weed scientists, extension specialists, and crop consults to identify the most common and troublesome weed species in major agronomic and horticultural crops in the US. According to the most recent data (2019) for fruit crops (Surveys | Weed Science Society of America (wssa.net)), perennial weeds like field bindweed (*Convolvulus arvensis*), hedge bindweed (C*alystegia sepium*), Canada thistle (*Cirsium arvense*), poison ivy (*Toxicodendron radicans*), and goldenrods (*Solidago spp*.), among others, are significant concerns in the Northeastern US.

Weed control must begin ahead of new orchard planting if perennial species are present. This timing allows orchard managers to make good use of deep, frequent cultivation and herbicides to deplete nutrient reserves stored in the weed's underground structures. Frequency/consistency is key for managing perennial weeds. Growers should prevent perennials from reestablishing and replenishing stored carbohydrates that were spent regenerating following cutting, cultivating, or spraying. For many perennial species, it is recommended that control efforts be repeated every 10 to 14 days to "starve" underground structures. It may take months to years to effectively deplete the energy reserves, so early planning is crucial to maximize the efficacy of control practices. Remember that soil disturbance can facilitate the spread of perennial weeds by dispersing root fragments, rhizomes, tubers, and seed on field equipment. Once land preparation and pre-plant weed control practices are complete, a strong orchard sod that will be weed suppressive should be established.

Across all commodities in the US, herbicides are the most used tool for managing unwanted vegetation. This includes in the weed-free strip that occurs under tree fruit canopies. For the control of annual species, soil-applied preemergence herbicides can be effective tools for preventing weed establishment. Except for seedlings, these chemistries are largely ineffective for suppressing perennial growth originating from crowns, root buds, rhizomes, or bulbs. Dichlobenil (Casoron) can have activity against perennial weeds, but the product must be used

repeatedly over time to be truly effective against many species. Consequently, this leaves only the use of postemergence products with respect to chemical weed management. Pay attention to how postemergence products work. For example, paraquat (Gramoxone) may provide very good burndown of both perennial broadleaf and grass species, but the control will be short lived as it is only a contact herbicide. Systemic herbicides like glyphosate (Roundup), clopyralid (Stinger), 2,4-D, etc…mill be translocated in the target plants, including to the roots, and can provide lengthier suppression. Always follow label guidelines regarding tank mixtures. Some herbicide combinations can be antagonistic, resulting in reduce weed control efficacy.

The following are some general notes about postemergence herbicide use:

- Understand perennial weed biology and ecology to treatments more effectively and understand that not all perennial species are sensitive to control at the same time. For example, Canada thistle is sensitive to control in spring and fall, whereas field bindweed is sensitive and summer and fall.
- Pay attention to spectrum of use/selectivity; not all products are equally effective against all species. For example, Stinger is effective against Canada thistle and other members of the aster family, but not bindweeds; WSSA Group 1 herbicides can work against perennial grasses, but not yellow nutsedge.
- Stressed plants may be less sensitive to treatments (e.g. especially a concern with systemic herbicides).
- Even when systemic herbicides are applied, perennial weeds will require multiple treatments for suppression.
- Postemergence herbicides may require spray tank additives (such as surfactants) to maximize control efficacy. Water quality and pH can also affect performance.
- Optimal spray volumes (more is not always better) and appropriate nozzle selection can vary among herbicides.
- Rotate herbicide modes of action as is possible and use alternate control strategies when appropriate for weed suppression. Perennial weeds are not immune to the selective forces that drive the evolution of resistance.
- Prevent sprays from contacting crop roots, green bark, foliage, flowers, or fruits.

Always follow the labels to maximize weed control and crop safety, reduce off-target movement, and minimize the potential for unnecessary exposure.

Weed control options may include the use of non-chemical control practices, especially when trees are young and more sensitive to injury. Mowing sod strips can be effective at suppressing erect weed species, but plants with a prostrate habit, will escape under mower blades. Mulching can be suppressive, but many perennials will be able to grow through material as it breaks down. Hand weeding/removal is time consuming but may be the best (or only) option for woody perennial plants or vining plants that become entangled around trunks and branches; in the case of dangerous species, like poison ivy, laborers should follow best management practices to prevent injury.

Soil moisture readings…
What they mean and how to interpret them to make irrigation decisions

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This document discusses the interpretation of soil moisture readings. It is a sequel of the "Soil Moisture is Money in the Bank" document on this Proceeding.

A well designed and managed irrigation system reduces water loss to evaporation, deep percolation, and runoff and minimizes erosion from applied water. Application of an effective irrigation water management plan and irrigation scheduling system based on soil moisture monitoring will reduce the waste of irrigation water, improve water use efficiency, and reduce the total pollutant discharge from an irrigation system. An effective irrigation scheduling system based on soil moisture monitoring focuses on managing the timing, amount and location of water applied to match crop water needs. Among the benefits of proper irrigation scheduling are improved crop yield and/or quality, conservation of water and energy, and lower production costs.

The amount of water that should be applied during irrigation depends on the current moisture content in the root zone and the amount of water it takes to "fill" the root zone (or bring the soil up to field capacity). Maintaining a higher soil moisture level typically does not require more irrigation water for the season, just more frequent and smaller irrigation periods. Irrigation is a daily practice that can be made highly efficient with the use of soil moisture sensors along with careful attention to the irrigation function and automation.

Irrigators should place soil moisture sensors according to the manufacturer's instructions at 1 to 3 stations and at 2 to 3 depths at each monitoring station, for a total of up to 9 sensors per representative field. When doing manual readings, check the sensors at least three times per week, such as Monday- Wednesday- Friday, and during irrigation events. Record the data on a chart for analysis at the end of the season. Also, many growers find it helpful to verify soil moisture with a soil sample taken with a probe from close by, at least in the first season or until confidence is gained in using the sensors. Wireless soil moisture monitoring systems with online deployment are routinely recommended over manual data recorders.

The soil moisture measurement to set an irrigation event will depend on the soil texture, management depth and measuring system. Soil moisture monitoring devices can directly or indirectly measure soil water. Directly measured soil water is often expressed as a percentage and indirectly measured soil water is often expressed with units of pressure (such as Atmosphere (ATM), Centibars (cb) or Kilopascals (kPa)). To properly interpret soil moisture readings, irrigators need to understand the concepts of field capacity, wilting point and maximum allowable depletion as described on the "Soil Moisture is Money in the Bank" document on this Proceeding.

The most common soil moisture sensor in New England is the Watermark which indirectly measure soil moisture in the form of soil tension (suction in soil -negative pressure-) and provide

readings in Centibars (cb) or Kilopascals (kPa). Watermark recommends irrigating when the management depth sensor reads 20 to 30 centibars in soils that are in the sandy loam range and when the management depth sensor read 30-40 centibars in soils that are in the silt loam range. End irrigation when the sensor at target depth shows a full soil profile (10 to 15 centibars when using Watermark sensors), being careful not to over-irrigate. Initially irrigate according to the manufacturer's guidance and seek to determine the soil tension that represents field capacity and wilting point for the site-specific soil texture where the Watermark sensor is installed. The irrigation run time to fill up the soil water profile between management allowable depletion and field capacity should be fine-tuned with experience.

Soil moisture monitoring devices that collect a direct measurement of soil moisture often require a specific understanding of the soil texture where the devise is installed to be able to accurately set irrigation intervals. For instance, on a fine sandy loam soil may show field capacity at 20% soil moisture and permanent wilting point at 8%, leaving 12% of available soil moisture. Then for vegetable crops, irrigation should be set to happen when soil moisture approaches 16% (12% soil moisture * 35% MAD = 4.2% allowable depletion, then 20% field capacity – 4.2% depletion = 15.8% soil moisture for irrigation set point or about 16%).

In conclusion, soil moisture monitoring systems provide a direct or indirect measurement of soil water at a given depth which the irrigator can use to determine when to irrigate according to the soil texture. It is very important for the irrigator to have a predetermined notion of the boundaries of soil available water (field capacity and wilting point) for the given soil texture to be able to set a management allowable depletion that will trigger irrigation events.

Question those assumptions:
Success with modern orchard systems demands attention to the details.

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The adoption of high density orchard systems in the past two or three decades has changed both the architecture of orchards as well as the economics of producing tree fruit. Past traditional orchards consisted of freestanding central leader (FSCL) trees on semidwarf rootstocks that may have been planted twelve, fifteen, even twenty feet apart in the rows and with wide row spacing from sixteen to twenty four feet. Such trees were large- certainly smaller than the sprawling 'standard' trees of yesteryear, but they were unmistakable as trees, with deep root systems, strong, broad trunks, and permanent scaffold limbs that could hold up to a few hundred pounds each. Tree densities of 150-400 trees per acre are common in FSCL systems.

Modern high density orchard systems split the essential components of the orchard, support and fruit bearing area, into two separate structures. These systems are dependent on a trellis system- the stronger and more engineered the better- that replaces the robust trunk and scaffold system that is grown on the FSCL trees themselves. That system of posts and wires provides support for smaller trees with narrow canopies and, aside from a central, permanent trunk, a bearing surface almost entirely made up of young, fruitful wood. This tall spindle (TS) and similar system requires substantially greater upfront investment, as tree numbers tend to be in the 800-1200 tree per acre range, and the grower must install a trellis system at or soon after planting. Essentially, a FSCL system 'grows' its support system in the first 3-5 years as the trees are cropped minimally to encourage development of a strong framework to support a crop that develops into full production in years 5-7, or sometimes later. By installing that support system in a TS orchard, growers can allow trees to set a saleable crop earlier because the trees do not need to hold up the weight of their own crop.

Long-term profitability in orchard systems is dependent on a number of factors. Initial cost, annual management cost, crop yield, annual bearing habit, and fruit price are critical factors that growers commonly make assumptions around that help them to make a decision which will pay off in ten, twenty, or more years. The accuracy and validity of these assumptions must be carefully considered when entering into a long-term investment such as an orchard.

Costs reported for orchard establishment in TS systems typically fall in the range of $25,000 – 30,000 per acre, which is *not* inclusive of initial land purchase. These compare to $5,000-8,000 for FSCL systems in which fewer trees are purchased and no trellis system is installed. However, these values may not reflect recent increases in material and labor costs. The substantial difference in installation costs between lower- and higher-density systems changes the need for orchard performance in regard to tree precocity, fruit price, and management costs.

A common method used to evaluate long-term investments such as orchards is using the *net present value* (NPV) approach. NPV is a cumulative annual modeling too in which annual costs and returns (annual net value) are accumulated over time. Those returns are adjusted using a discount rate which is equivalent to the minimum acceptable rate of return. The effect of this

adjustment is to make a dollar received more valuable today than at a later date, and for a dollar spent tomorrow to be less costly (assuming that it is the same dollar) than a dollar today.

Typical assumptions that are applied to long-term analysis of TS systems include trees reaching full production by year three or four at the latest and consistent crop yield at maturity of 1000 bushels per acre. This contrasts to tree precocity of 5-7 years to reach full production and mature crop yield of 800 bushels per acre in FSCL systems. After 20 years of cumulative costs and returns, the TS system, with assumed installation cost of $25,000 per acre is worth roughly double the NPV of the FSCL orchard which has an assumed installation cost of $6,250 per acre. In this case, a greater investment in TS is offset by greater and earlier returns so that over time, the economic performance is better under a TS system.

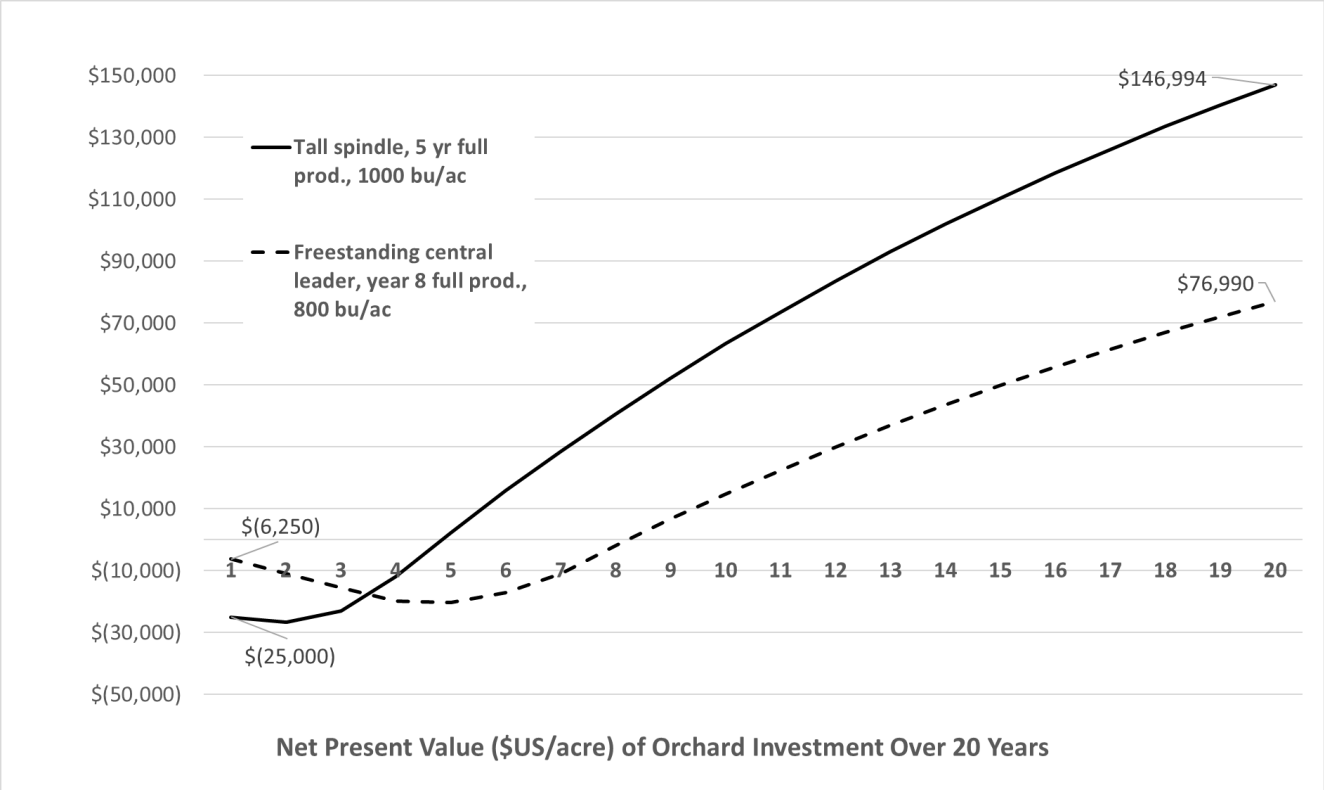

Figure 1. Difference in long-term accumulated value of TS and FSCL given 'standard' assumptions

However, some assumptions don't always pan out in reality. The cost of poles, wire, and other trellis supplies has increased substantially since 2019, not to mention normal cost increases since the $25,000 per acre number was first suggested over ten years ago. Tree costs have increased at virtually all nurseries, and labor costs have increased in virtually all sectors of the economy. If installation and management costs are increased 20% for all systems, the performance difference between TS and FSCL decreases. Add to that a loss in precocity, maybe from severe pruning in the early years due to fire blight infection or poor growth in a replant situation or reduced mature yield from a low yield variety (Honevcrisp, anyone?) and the performance differences between TS and FSCL may become even closer.

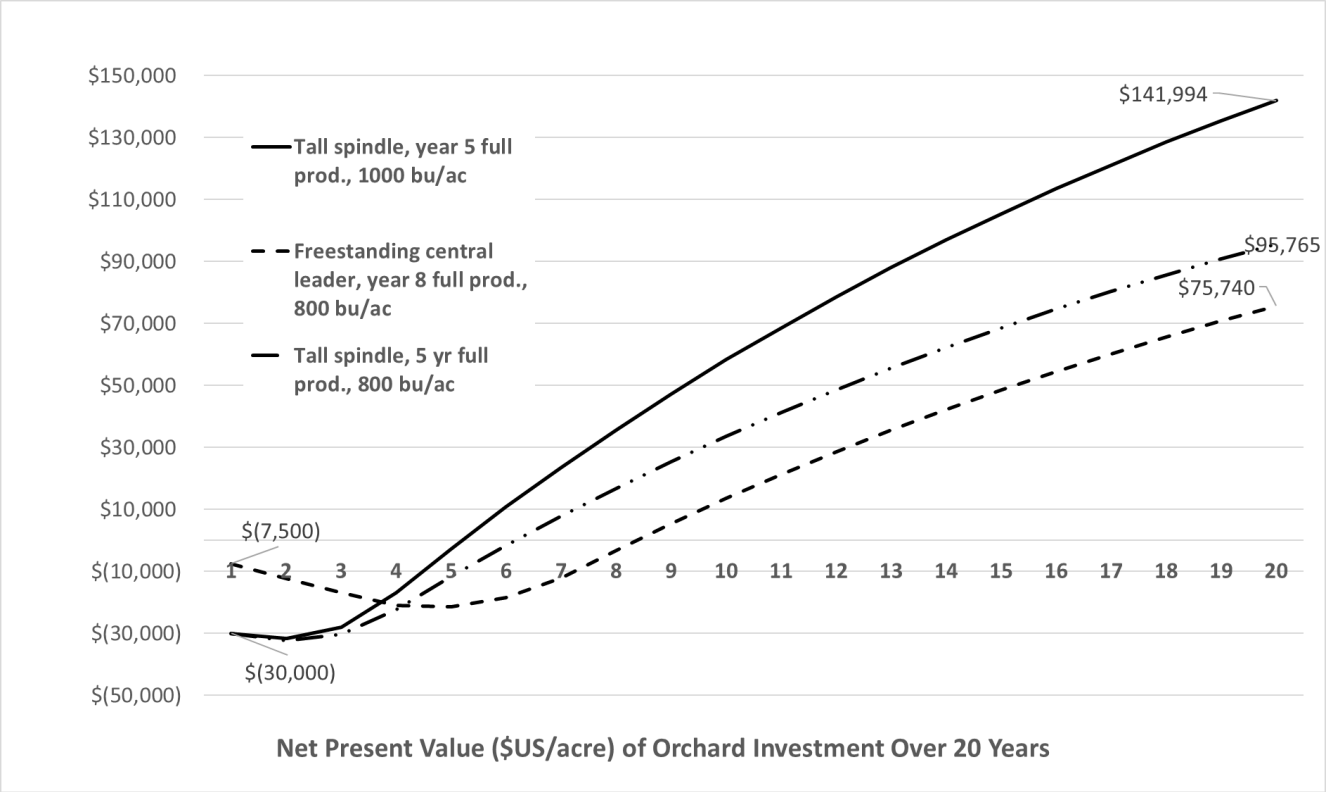

Figure 2. Difference in long-term accumulated value of TS and FSCL given 'reduced yield and precocity' conditions

Certain conditions can really affect the potential long-term performance of an orchard system. Reduced precocity, reduced mature yield, tree decline, biennial bearing habit, and other factors can make the difference between a high-value orchard investment and a poorly-performing one. Growers may want to consider whether their skill set, site conditions, management intensity, and tree selection will provide the optimum outputs for the money invested in in a new orchard over its productive lifespan.

For more information, scan this code with your smartphone to go to the UVM Fruit Program website.

Overlooked Risks in Water Systems on Produce Farms

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The presentation is designed to help farms think critically about their agricultural water systems and identify food safety risks that they may not have considered before. Eight examples are highlighted from Tucker's experiences as a farm inspector. The presentation builds on key concepts taught in the Produce Safety Alliance Grower Training course and can be thought of as a refresher training for those who have taken the course or an introduction for those who haven't.

Why it matters

Water can be a source of contamination to fresh produce and has been a factor in several major produce outbreaks nationwide. FDA's Food Safety Modernization Act establishes the minimum food safety standards which farms must follow and includes a chapter on agricultural water called Subpart E. The good news is that growers can take proactive steps to prevent contamination by focusing on how they use water in the field, during harvest, in the pack house, and in storage. Harvest and post-harvest water regulatory requirements come into effect for the largest size farms in January 2023, so now is good time to review the topic. Preharvest requirements are under revision and are expected to be finalized soon. The purpose of this presentation is to share practical tips, but it is not meant to be a comprehensive guide to the regulations. Contact your state Department of Agriculture or the FDA to learn more about specific requirements. Vermont growers can contact Tucker directly at tucker.diego@vermont.gov.

Example 1
Recognize High Risk Irrigation Practices

This first example is about learning to recognize how a combination of factors can cause certain irrigation practices to be considered higher risk than others. This exercise is helpful if you grow many different crops with different application methods and aren't sure where to focus your efforts. Four crops are listed in the table below with different application methods, water sources, and intervals between when water is last applied and when the crop is harvested. Which crop would you rank as higher risk than the others? Why?

Crop	**Water application method**	**Water source**	**Interval between last application and harvest**
Brassicas	Drip	River	1 week
Strawberries	Overhead	River	3 days
Potatoes	Overhead	River	2 weeks
Apples	Spray	Pond	2 weeks

The correct answer is strawberries. This is because the water source is surface water which we assume has some amount of generic *E. coli* bacteria, the water comes into direct

contact with the crop which grows low to the ground and is susceptible to backsplash from the soil, and the crop has the shortest interval between when it's last irrigated and harvested. This short interval doesn't allow much time for pathogens present in the water to die off naturally from sun and wind exposure. This means that you could focus on testing the river water to establish a microbial water quality profile, change to an indirect irrigation method such as subsoil drip, and/or extend the irrigation to harvest interval if practical for the crop.

Example 2
Identify Nearby & Upstream Hazards to Surface Water Sources

This second example is for farms that irrigate from a surface water source such as a river or stream. Because surface water is higher risk than protected ground water sources, you should assess hazards that could be introduced into the water from nearby land or upstream activities. If you're not sure where to start, focus on identifying potential hazard such as those listed below that could contaminate the water in the first one to two miles upstream from your irrigation pump:

- Livestock with direct access to water
- Runoff from manure piles or manure spreading
- Municipal wastewater discharges
- Residential or commercial septic failures
- Other activities that could leak large volumes of human or animal feces into the water

This may seem like a daunting task, but you can use existing resources and experts to help you. For example, the VT Dept of Environmental Conservation allows you to sign up to receive alerts when there is a sewer overflow from a treatment facility. If your farm is downstream from one of these locations, you can be alerted when there has been a discharge so you can take precautions. Another example is the Connecticut River Conservancy which is an organization that shares water test results from dozens of locations along the Connecticut River watershed in VT, NH, MA, and CT.

Identifying potential hazards can help you choose which proactive steps to take to make your water safer. FSMA refers to this as creating an Agricultural Water Assessment. Examples 1 and 2 are not meant to be a substitute for an Agricultural Water Assessment but can complement that work. For more information on this topic refer to Module 5.1 in the Produce Safety Alliance Grower Training curriculum.

Water use on farms isn't limited to irrigation. The next six examples will examine water use during growing, packing, and storage.

Example 3
Sprays

Spray water is considered agricultural water and must be applied in a safe manner. As part of an annual water distribution system check you should make sure spray tanks and emitters are clean, in good repair, and will not cause potential contamination to produce.

Before you spray a product that includes ingredients of animal origin, such as fish emulsion, make sure you know the product has been treated to eliminate pathogens and keep documentation from the supplier on file. If you plan to mix up your own agricultural tea or spray that includes animal ingredients, check with your state Department of Agriculture first so you know what restrictions may apply.

Example 4
Ice

Ice used for packing or cooling is agricultural water when it comes into direct contact with the crop. Ice must meet post-harvest water standards, which means it must be from a non-surface water source with no detectable generic *E. coli*. Extra care should be taken to keep the bottom and sides of harvest containers clean so that ice melt doesn't spread soil and debris to containers below when stacked on top of one another. For the same reason, avoid stacking iced containers on top of non-iced containers. Care should also be taken to keep ice clean if it's brought into the field for field packing. A dedicated ice container with a lid and clean ice scoop are essential.

Example 5
Floors and Drains

Wash water from equipment and sinks should be plumbed or diverted to a drain to avoid excessive pooling on floors in packing houses. Floors themselves should be in good repair, cleanable, and sloped to allow water to drain easily. Allow floors to dry out whenever possible. The goal is to avoid pooled water and potential cross contamination from a wet floor to workers' boots and equipment as they move around your buildings.

Example 6
Condensation and Drip

Condensation in coolers can be difficult to manage. However, it's important to recognize condensation and drip as sources of potential contamination to produce and packing material. Ceilings that are prone to surface condensation should be constructed of easily cleanable material and kept clean. Avoid storing produce and packing material directly under areas you know will accumulate condensation. Ensure that the bottom drip pans of AC units are plumbed to a drain and aren't allowed to drip directly onto produce as this could be a direct source of contamination. Keep AC units inspected and serviced regularly to avoid icing up.

Example 7
Water Treatment Systems

If you use a water treatment system such as a UV light for your post-harvest water, make sure it is designed and install correctly and regularly inspected and maintained. Keep a maintenance log when you last replaced a bulb or made a repair. If you're not comfortable installing or maintaining the system, hire a professional to do it for you. Also, it's always better to fix a problem at the source. If you know there's a problem with your water source, speak with

a service provider to assess your options. You may have a cracked well head or casing in need of repair.

Example 8
Hand sinks

Last but not least, don't forget about the importance of hand sinks. Remember that workers should wash their hands every time before starting a task while handling produce and whenever their hands become unclean. Hand sinks should made of adequate materials and be kept supplied with water that meets the post-harvest water standards, soap, paper towels, and a waste bin. Hand sinks should be accessible to workers whenever they are handling produce, including during harvest.

Key Sources

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High Tunnel Raspberries @4Corners Farm

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4Corners Farm is a diversified agriculture farm in Newbury, Vt. We specialize in many different types of fruits and vegetables. 4corners farm started growing raspberries in 2007 after a visit to England where we toured farms using a new low-cost tunnel called Haygrove. We were eager to try these tunnels out to see how they would work for our climate. Excited with what we saw in 2006 we put the tunnel up in spring of 2007 and planted that same year. We started picking our first crop in 2008 and since then we've had 15 years of successful fruiting of fall raspberries from four 400-foot rows.

On year 12 the raspberries did not yield as much and with our experience and knowledge gained from other growers, we feared that soon the crop would become unprofitable. In preparation for the future, we decided to plant three more 400-foot rows of fall bearing raspberries with the plan to pull out the plants in the original house. The new house started producing the very next year and the original house also produced well. With additional plant management, including adding compost and replacing leaky drip lines, we ended up keeping the original house and now have 7 rows of fall raspberries in production and one row of summer producing fruit.

By the use of Haygrove tunnels we eliminate the disease that is weather dependent such as botrytis. Being able to control the growing environment allows a better yield. Other preventative measures include managing the population of two spotted spider mites and spotted wing drosophila. We also have control over the water supply to ensure the highest yield. Through our experimentation and process we have designed a more efficient way of trellising our plants for easier harvest.

In the presentation I look forward to discussing in more detail our experience with growing raspberries, how we've managed the plants and what has worked best for us to achieve the highest profit margin for our farm. I will share our experience with trying to harvest both summer and fall crops and the challenges we face in our climate. We will be talking about the basics of growing summer and fall raspberries in the northeast and how to keep the correct spacing, trellising and harvesting of raspberries under tunnel in Vermont.

The Raspberry Plant: What You Should Know[1]

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Raspberries belong to a diverse group of plants in the rose family that are collectively referred to as brambles. The raspberry varieties we grow today are a mix of selections from Europe, North America and Asia, which were collected from the wild over the past two centuries and crossed with one another as people spread around the globe and brought raspberry plants with them. This cross breeding has resulted in cultivars today that have large, flavorful fruit, bright red color and high yields. Selective breeding has also developed a wide window of harvest times, good cold tolerance, disease resistance, thornlessness and the primocane fruiting (everbearing) habit.

Raspberries are considered to be woody shrubs that have a perennial root system and crown, which can live for many years, and biennial shoots, called canes, that emerge from buds on the roots or crown and live for two years. The roots of raspberry plants are shallow, with more than half of the roots in the top ten inches of the soil surface and nearly 100% of the roots less than 20 inches deep. The roots spread widely from the crowns, and many form adventitious buds from which new canes will develop. This is how raspberries spread themselves across a field in a relatively short amount of time. Raspberry roots also act as reservoirs for starch, sugar and nutrients, which support that plant through the winter and other stressful events, such as drought.

The biennial canes of raspberries can originate from buds on the woody crowns at the base of the plant, or from buds formed on the roots. These buds are often formed in the late summer and fall, remaining dormant until spring. Bud break is enhanced by a chilling period (temperatures between 25° and 40° F), which is why we see a heavy flush of new growth in the spring, after the buds have been chilled through the winter. The green shoots break from the ground in the spring and grow rapidly, often reaching six feet or more before the end of the season. During this first year of growth they are called primocanes. In this first season, buds form in the leaf axils (every place a leaf meets the stem). These buds, called axillary buds, usually remain dormant though the first season, go through the winter and break early in the second season to form lateral branches, which bear fruit buds that, in turn, will form the flowers and fruit. The amount of chilling time required for optimum bud break varies considerably among cultivars, ranging from 400 to1200 hours. Cultivars requiring more chilling hours tend to be better equipped to survive long winters, but may perform poorly in climates where the winters are short and mild, because they do not receive adequate chilling. In the second season, or bearing year, the canes are called floricanes. Once the fruit on the floricanes has matured, the canes will senesce and die. At the same time, primocanes are growing, which will provide a crop the following year. With everbearing, or fall fruiting cultivars, axillary buds formed on the primocanes do not all remain dormant. Some buds at the tips of these first year canes will break and form shortened fruiting lateral branches that bear fruit late in the summer or fall. This is

[1] Much of this article was adapted from a chapter appearing in the Raspberry and Blackberry Production Guide for the Northeast, Midwest and Eastern Canada (NRAES-35), L. Bushway, M. Pritts and D. Handley, eds. 2008.

why everbearing varieties are also referred to as primocane fruiting varieties. The buds that remain dormant lower down on the canes will overwinter and fruit the following year as a typical floricane type. So, for everbearing types, the typical summer crop is harvested from the second year canes or floricanes, and a fall crop is harvested from the first year canes or primocanes. The overall yield from summer bearing varieties and everbearing varieties is similar, but the distribution of the primocane harvest occurs over two different times.

Raspberry flowers have five sepals that lie beneath five white petals. Many stamens surround a center cluster of 100 or more pistils in each flower. For pollination to occur, pollen must be transferred from the stamens (male) to the pistils (female). Raspberries are self-fertile, so pollen from another plant, or cross-pollination, is not necessary for fruit development. The flowers are very attractive to pollinating insects, however, and some studies have shown that insect pollination can improve both yield and fruit quality. Following pollination, a seed will form within a fleshy drupelet. Each raspberry will consist of 75 to 125 drupelets, held together by many small hairs, which surround the receptacle or torus. Each individual drupelet has the same basic structure as a peach or cherry fruit, which are called "drupes". Because each raspberry consists of numerous drupelets, they are considered aggregate fruit.

Raspberries respond environmental cues. Short daylengths in the late summer and fall stimulate flower bud development and inhibit new cane growth. Light intensity can also have a significant effect on yield. When individual canes receive more light they produce more fruit buds and have higher yields. North-south orientation of raspberry rows intercepts more light than an east-west orientation and therefore produces higher yields. Narrow plant rows (18-24") allow individual canes to receive more light and thus produce more fruit than wider rows in which the canes in the middle receive very little light. Trellising the canes, especially with a system that spreads the canes into a V-shape, leaving the row middle open, will greatly improve light interception and increase the productivity of the canes. In addition, V-type trellising will improve spray coverage and make harvest of the floricanes more efficient by reducing interference from the primocanes.

Temperature also influences raspberry growth. Extended cool temperatures (25°to 40°F) are required for buds to meet their chilling requirement before breaking dormancy, but temperatures below 10°F can injure buds of less hardy varieties and temperatures below -15°F can damage even the most hardy cultivars. Warm temperatures in the late winter can cause canes to deacclimate and break dormancy prematurely. When this happens a sudden drop in temperature could cause bud and/or vascular damage to the canes, even when a winter has been relatively mild otherwise. During the growing season, raspberries grow best at temperatures close to 70°F. When temperatures are over 80°F growth will slow or stop, reducing the plant's ability to make and store carbohydrates and other compounds required for sustained growth and productivity.

Raspberry plants express a wide range of growth and fruiting characteristics, based upon the cultivar and the environment in which they are grown. Different cultivars have been bred and developed to grow all over the world, and may be narrowly adapted to a specific region. Cultivars developed in one part of the world may not be suitable for production in another region. Understanding the basic anatomy and functions of the raspberry plant and its

relationship with the environment can help farmers develop cultural practices that encourage optimum plant growth and productivity.

Long Cane Raspberry Substrate Culture

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Long cane raspberry production is an emerging raspberry production system in Ontario that growers are gaining interest in. This system is popular in Europe and is a combination of soilless production and protected culture, allowing growers to produce consistent, high-quality raspberries season-long.

What is it?

Long cane raspberries are grown out of the soil in substrate-filled pots. This reduces the risk of soil diseases, the need for crop rotation, and allows for production on poor soils. The potted plants can also be moved into cold storage for the winter, allowing Ontario growers access to cultivars that are typically less winter-hardy. Growers are also able to take advantage of the potted system and stagger when the dormant long canes are moved out of cold storage and into the high tunnel for fruiting, allowing growers to extend the season and produce high quality, consistent berries season-long.

Production

Fruiting canes are grown to 1.8-2m tall at the nursery. Alternatively, growers can grow their own long canes from plug plants in smaller, 1.8L pots. After storing the canes in cold storage (-1.5^{o}C) for the winter two canes per pot are planted in 7-10 L pots, and established at a density of three pots per linear meter in tunnels or under umbrellas. It is important for the pots to be raised up or separated from the soil to reduce any risk of soil pathogens. The canes are supported by bamboo and often mesh netting is set up to support the laterals. Growers can expect harvest to begin 10-12 weeks after moving the canes out of cold storage. The cultivars being grown in Ontario include Tulameen and Glen Ample, with interest in other cultivars including primocane-fruiting cultivars.

After harvest growers can either discard the plants or move the pots outdoors to grow primocanes next season.

Protected systems

Long cane raspberries are typically grown in high tunnels or umbrella-type protected structures. These structures provide protection from wind, hail, and rain, reducing disease pressure and the need for fungicides, and improving fruit quality. The warmer conditions in the tunnels also provide season extension in the spring and fall. Ideally, these structures should have the option for ventilation to help manage the temperatures during hot summer days.

This system includes a high establishment cost and requires a lot of technical knowledge. Various factors need to be carefully considered and managed to be successful, including irrigation, fertigation, and substrate choice. However, if well-managed, growers can produce high-quality raspberries in a high-yielding, profitable system.

Cut and Carry Cover Cropping

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About our Farm:

Owned and operated by Spencer and Jennifer Blackwell, Elmer Farm is a certified organic farm producing five acres of mixed vegetable crops that serve local markets in and around Middlebury, Vermont. The farm offers an on-farm 'Farmstand credit CSA' with a substantial pick your own component comprising approximately twenty five percent of its annual sales. The remaining seventy five percent of produce is sold directly to restaurants and retail locations. In addition to the owners' labor, the production crew is composed of part time students and agricultural professionals from the Middlebury area to make up an equivalent of two and a half full time employees from April through December. Community resilience and resource conservation are paramount in much of the decision making concerning cropping and marketing options.

Cover Cropping:

The most effective tool to promote resource conservation in vegetable farming is cover cropping. The production of cash crops on Elmer Farm begins years in advance with custom tailored cover crops to set the stage for high quality and high yields. With thirty different cash crops and fifteen different cover crops, the species mixes, sequencing and planting techniques of the cover crops is ever changing and evolving. The basic plan however, is to keep all of the fifteen acres through which cash crops are rotated in one of three general states of cover. First is a multi-year, perennial, legume rich sod; next is a half year, annual grass, legume and brassica mix; and the third scenario is a short duration, nutrient foraging and weed smothering annual.

The cover crops are terminated by various means (Primary tillage, Strip tillage, Surface tillage, Aggressive mowing, Tarping/solarizing) when they are at a weak stage in their life cycle or at natural senescence. Ideally this is at the same time as planting the next crop. However, regardless of how efficient the transition from one crop to the next, inevitably there is a period of time while the young plants get established where some amount of bare ground is allowed direct exposure to sun, wind and rain.

Mulching:

Due to the deleterious effects of environmental forces on soil life and the proliferation of weeds during crop transitions, Elmer Farm has implemented an intensive protocol of mulching to shield bare soil and protect microorganisms that are providing nutrient transfer and disease resistance. In most cases the mulching is also providing a multi-tiered benefit by nearly eliminating the need for tractor cultivation, slowly increasing nutrient levels and soil organic matter in a balanced manner (Table 1.), and preventing soil splashing.

Table 1.

Heavy Silage Applied Over Two Years (Plot Size 1/16th Ac.)	Test Date	PH	OM_ Pct	Avail _P	K	Ca	Mg	ECEC
Plot A - No Mulch	4/1/22	6.7	3.1	20.9	202	1336	118	8.2
Plot B- 76 Tons/Acre (2020 +2021)	4/1/22	6.9	3.9	47.8	267	1662	149	10.2

Mulching:

Elmer Farm's supply of mulch comes from its own cover crops as well as fresh wilted hay silage from adjacent hay fields and spoiled (waste) hay silage from a neighboring dairy. The farm's own cover crops are used in the place where they were grown with the exception of robust stands of winter rye. The winter rye is reasonably efficient to chop with an antiquated flail chopper and carry to another part of the farm using a side discharge forage wagon. The efficiency of modern haying equipment has proved to make any other attempts to cut and carry mulch from one vegetable field to another futile. Not only can the modern equipment quickly provide vastly greater volumes, but the ability for a powerful forage chopper to reduce the size of any blade of grass to less than two inches considerably improves the handling and functionality of the mulch.

The C:N ratio of mulch plays a huge role in how well it facilitates vegetable growth. A layered approach has proven to be most successful. The base layer is composed of lush N rich materials in contact with the soil. Subsequent layers are ideally of a more lignified material. One proven method the farm employs is to first prepare a smooth appropriately shaped vegetable bed in which a predominantly legume cover mix such as field peas and oats or yellow blossom sweet clover and tillage radish is planted. When that cover is knee to chest high and the legumes are showing the first signs of flowering the crop is pulverized by several passes with a flail mower. The rear roller on the mower squeezes the material into an even mat. Transferred mulch is then layered on top to fill in any cracks and protect the high nitrogen content in the base layer from quickly volatizing. The farm uses a modified corn planter to cut strips into the mulch to facilitate planting. If weeds do take hold, mulch of a fine consistency does allow for tractor cultivation, although the disturbance to the layers is ideally avoided. Generally hand weeding is a better and sometimes quicker solution. Additionally, with a low tech modification to a double beater rear discharge box spreader, the farm is able to add subsequent layers of mulch in precise strips between up to three rows of young vegetable seedlings on a six foot bed.

Cost Benefit Analysis:

Developing a cost benefit analysis for the mulching protocol has proved difficult due to the intangible nature of the benefits. For example it is exceedingly difficult to conclusively attribute the absence of a pest or disease to the mulch. Also, hand weeding seems to have been significantly reduced, but without detailed records this is a subjective measurement. One metric that is abundantly clear is that the mulching displaces almost all tractor cultivation. It has also allowed for maintained fertility while using much less bagged fertilizer. Another benefit of using the locally sourced natural material for mulch is the farm has been able to totally eliminate the use of plastic mulch. (It does still use landscape fabric for some heat loving early crops)

Listed below are some of the costs associated with cut and carry mulching at Elmer Farm. (Table 2.) Also listed are some data from the 2022 season. (Table 3.)

Table 2.

Heavy Application To Fully Smother Bare Ground	Hrs.	Acres Cut	Acres Covered	Machinery+Labor ($65) Cost/ Acre Covered	Mulch Cost / Ton	Tons applied per acre	Mulch Cost per Acre	Total Cost Per Acre
In house Rye Straw Cut and Carry	32	8	1	$2,080	$0	40	$0.00	$2,080
Hay Silage Spreading (40t/ac.)	6	n/a	1	$390	$50	40	$2,000	$2,390
*Weights are approximated based on volume and moisture content of 65%.								

Table 3.

Hay Silage - 2022	**Vol.**	**Cost**	**Rye Straw - 2022**	**Vol.**	**Cost**
Total Acreage Mulched (ac.)	6.25		Total Acreage Cut (ac.)	1.44	
Total mulch Applied (Tons)	135	$8060	Total Acreage Mulched (ac.)	0.18	
Average Rate (t) / Acre	21.6	$1,290	Total mulch Applied (Tons)	7.2	
High Rate (t) / Acre	55	$3286	Ave. Application Tons / Acre	40	
Low Rate (t) / Acre	12.5	$747	Total Cost		$374

Planting Cover Crops for Pollinator Habitat

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Yield and marketability of many fruit and vegetable crops are dependent on, or significantly enhanced by, animal mediated pollination. There are several ways to support insect pollinators that do much of this work on farms by providing nesting habitat and diverse food sources of nectar, pollen, and clean water. These resources can be made available with permanent and temporary pollinator habitat plantings, like with the installation of hedgerows or planting of cover crops; tilling, mulching, and mowing practices; and integrated pest and pollinator management to avoid pesticide harm to pollinators.

A familiar farm management practice is the use of cover crops. Cover crops are well-known to contribute to the maintenance of soil health. Another benefit of cover crops is their ability to provide resources that support pollinators. Pollinators require carbohydrates, proteins, fats, vitamins, and minerals. When allowed to flower, cover crops provide insect pollinators with these dietary resources in the form of pollen and nectar, while additionally providing shelter and protection to some.

One thing to consider when choosing cover crops for pollinator habitat is the plant variety. Insect pollinator mouth part physiology and cover crop floral design are characteristics that guide flower selection and resource accessibility. Flowers of legumes tend to have long, tubular corollas of varying depths and are most accessible to pollinators with tongues, like bees, butterflies, and moths. Some legume varietal options include the following:

- White clovers are accessible to many, including bees with shorter tongues, like honey bees. It is a highly valued nectar plant. Plant small to intermediate or medium type cultivars, such as 'Pinnacle' white clover, which are more tolerant to mowing, other farm traffic, and tend to flower more[1].
- Red clovers serve as a pollen resource for many bees. This clover has long corollas that limit nectar access to longer tongued insects, such as certain species of bumble bees. Plant medium type cultivars in mowed or trafficked areas[1].
- Birdsfoot trefoil and alfalfa varieties are other pollinator attractive legumes that support managed and wild bees, like the alfalfa leafcutter bee. Plant Empire-type varieties of birdsfoot trefoil, which have spreading and indeterminate growth habits favorable to mowed and trafficked field areas[2].

Notably, the following are some non-legume cover crops to consider that are valued as food and shelter for insect pollinators.

- Mustard and phacelia have “open access” blooms. The open-faced flowers are widely accessible to pollinators with and without tongues, like syrphid flies and lady beetles.
- Some “open access” blooming plants have hollow or pithy stems. When not incorporated and left undisturbed from fall through spring, these stem types can provide nesting habitat for certain bees and other insects where they can rear young and overwinter. Cover crop examples with this stem characteristic, that also providing food resources, include pollen producing sunflowers and buckwheat cover crops.

These and several other considerations of cover crop management for pollinators must also be balanced with other farm goals and resources. Single versus mixed cover crop stands, stand duration, timing of flowering, timing of termination, and cash crop rotations are just some of the layers for guiding decision making when using cover crops as a tool for farm health. With careful planning and an intimate understanding of your farm needs and cover crop varietal strengths and limitations, cover crops can contribute to the maintenance of soil health by reducing erosion, adding organic matter, cycling plant nutrients, enhancing soil structure, suppressing weeds, fixing nitrogen for subsequent cash crops, *and* support pollinator health. Visit UVM Extension’s pollinator resource page for more information, https://www.uvm.edu/extension/pollinator-resources.

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Upright versus prostrate growth habit of red and white clover.

Building up Sandy Soils with Cover Crops

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Root 5 Farm is a 38 acre organic vegetable farm located in Fairlee, Vermont along the banks of the Connecticut River. The soils are mostly Hadley, sandy loam. We grow about eight acres of mixed vegetables and six acres of cover crops each season with the rest of the acreage in wooded slopes and roads. Our bed dimensions are six foot wide by 100 and 200 long foot beds. We sell our vegetables through a 400 member CSA program and to local co-op grocers and restaurants.

Due to pre-existing high phosphorus levels found in our soils we have focused on using cover crops and supplemental bagged amendments for our fertility program and soil health benefits. In recent years we have set about to improve our cover cropping methods in order to maintain and improve our organic matter and nitrogen production.

In words spoken to me just the other day by Vern Grubenger, "Nature abhors a vacuum". Or to parafrase Will Bonsall, "mother earth is modest and doesn't like to be nude". With these thoughts in our mind we attempt to have some sort of coverage on our fields at all times or at least attempt to reduce the amount of time between bare soil moments. Cover Crops grow organic matter, a crucial part of soil health and a limiting factor to highly productive soils.

Sandy soils have been described as being like a wood stove that has a fire in it with all the dampers and doors taken off the stove. Nutrients flow through our soils and are hard to keep around Organic matter is used up more easily and is a primary source for "free" nitrogen in soil microbial life. We use organic matter as a primary indicator of whether we are achieving our goals of soil health. We have set about to create a number of cover cropping techniques in an attempt to maintain or increase the organic matter in our soils.

Four cover crop systems that we use to maintain or build organic matter in our sandy soils:

1. *Long term covers.* These are areas that are in cover crop for more than one season, ideally for two full growing seasons. These covers are the most effective at building up organic matter if you have the time and patience and space.
    - Clovers: We prefer white clover for its ease of establishment in fall or early spring and for its traffic tolerance. This quality allows for multiple mowings through the season to top weeds if they overtop the clover. White clover is somewhat shade tolerant so it is a good candidate for overseeding into winter covers that will be mowed off later to release the clover for a long term cover. Covers are also great for insect forage.
    - TARA: timothy, alsike clover, red clover, and alfalfa. The real advantage to this cover is that it has a diverse set of species to cover the bases and ensure that a cover crop is established given whatever the conditions (drought, wet, cold, or perfect) are at the time of seeding. It can go many years, and can also be mowed many times.

2. *Cover cropping before and after vegetable crops during the growing season*:

- Early spring cropped, direct seeded areas have to come out of either bare soil or winter tarped areas from a late season crop from the previous year or from winter killed oats and peas. Transplanted crops can go into either these areas or into winter-killed sorghum sudan grass.
- Mid-season cropped-In areas can be seeded or transplanted into winter-killed sorghum sudan grass or winter-killed oats that were thick enough to suppress weeds till the time of bed preparation.
- Later mid season crops-We have used early spring oats and peas and then terminated them with enough time to allow for the beds to be prepared in time. Late season crops are often preceded by oats and peas until seeding time or oats and peas with a break of buckwheat as a way to keep disrupting the weed attempts to get a foothold.
- Preparing next season's growing areas- We use winter rye vetch after the crop comes out (timing ranges from mid summer to late fall) during the previous year's growing season. This mix overwinters and grows in early spring and flowers late June. We flail chop with a forage chopper to leave in place a thick mulch in place or collected for mulching other crops. We follow this with Sorghum Sudan Grass which ideally is ideally chopped at 2.5 feet tall to tiller then chopped and seeded to oats and peas or left to winter kill depending on the following crops timing. The trick to using sorghum sudan grass is getting the timing right for the next crop and it may be useful to terminate and seed to oats and peas. We have used a number of mixes in this time slot but have found sorghum sudan grass to be the best in dry soils and is a great biomass/ organic matter grower.

3. Mid-Summer quick cover: Buckwheat is used for warm, dry, mid-summer gaps (coming out of an early spring short season crop, or waiting for a late summer crop) easy to germinate in hot dry weather. Easy to terminate and incorporate. Make sure to mow and incorporate before buckwheat sets seed otherwise you'll have buckwheat coming up in your next crop.

Seeding equipment and soil preparation techniques:

Grain drill. We purchased a minimum till drill to reduce soil disturbance and to increase the quality of our cover cropping planting. Our other ways of establishing covers were leading to extra work and poor establishment. Even a cheap one wound be worth trying out.

Tarping. We use tarping to eliminate stale seeding practices, increase weed seed suppression, and hold onto nutrients.

Flail chopping. We use flail shopping to shred covers before incorporating to aid break down and to distribute the material being mowed across the area instead of windrowing like a rotary mower would do.

Stone Burier. We have also purchased a stone burier. It is a rototiller basically but it has allowed us to reduce the number of passes with other tools to form beds. Jury is still out to its effect on organic matter on our farm

Waiting. How long can you wait till you have to cover it or till it? In our experience we have been able to widen the window of time that winter killed oats and pea thatch can stay on the ground so long as it doesn't get you into trouble with your bed preparation for the market crop. A similar thought can be applied to mowed crops. Can they continue to grow in order for you to kill weeds while growing cover crops? However we tend to mow and incorporate covers that are nitrogen fixers on the same day in order to not lose the crucial nutrient. Also some covers can be very hard to incorporate or can lead to nitrogen tie up if left to dry and lignify. Know your covers and techniques you develop.

Growing covers to maturity to be able to reseed themselves. Sometimes it works out that the cover can be left to grow to maturity. We have had great success with this technique with both rye vetch and oats and peas. There are a few advantages to this technique. All it takes is a mower and some rain. Fingers crossed. It reduces soil turn over and soil disturbance. The mature plants lignify to create longer lasting organic matter. It is nice to see a cover or anything for that matter on the farm live to maturity. Finally, it is a cheap cover crop seed. If it doesn't work you can reseed and haven't lost much time especially if you have a minimum till drill.

Some of the disadvantages to this technique is that it is only as good as the first seeding job. There is no point in continuing a bad thing. Weeds can persist since they are not being killed between covers. If the first crop wasn't good the second seeding isn't going to be great either. Start over. Cover crop is relatively cheap as far as the other things we do and the advantages to the future crop can be significant. It can create a very dense stand after self seeding leeding to lodging or mold but we haven't seen that myself.

Covering Ground: Interseeded Cover Crops in Late Season Vegetables

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Abstract

Results from a survey about cover cropping practices on Maine farms (n= 27), showed that 77.8% of respondents (n=21) are limited in their ability to plant cover crops due to "late season cash crops coming out too late". 74.1% of respondents (n= 20) stated that research-based data about interseeding in the Northeast would help them with decision-making about late-season cover cropping. In response to those survey results, this project was developed to investigate best management practices associated with planting cover crops into standing, late-season vegetables. This three-year project launched during the 2022 growing season and will include a total of two years of replicated field trials. We are assessing the timing of seeding, seeding methods, and species selection. Trials are being conducted at Rogers Farm in Old Town, Maine, as well as on 4 collaborating farms throughout Southern Maine. We hypothesize that 1) Interseeding at an appropriate growth stage of sweet corn and fall cabbage (V5 and 21 days after transplanting respectively) will result in high cover crop biomass and with no negative effects on the crops; 2) Incorporation of cover crop seed into the soil at interseeding will result in the best cover crop germination, biomass, and weed control; and 3) Utilizing lower biomass cover crops such as annual ryegrass and crimson clover will minimize nutrient and water competition. Furthermore, we will develop evidence-based recommendations for interseeding cover crops into late-season vegetables, including equipment and logistical considerations.

Keywords: *Interseeding, late-season vegetables, cover crops, soil health*

Introduction

Vegetable farmers throughout Maine and northern New England contend with relatively short growing seasons. Every year, most farmers leave some portion of their lands bare over winter because late-season cash crops come out too late, preventing them from planting cover crops. Leaving their lands bare makes the soils susceptible to erosion, nutrient leaching and winter-annual-weed seed production (Pimentel et al. 1995; Sainju and Singh 1997; Sarrantonio and Gallandt, 2003). Climate change forecasts relevant to the northeast suggest that the region is likely to experience longer spring wet periods in the coming decades, making bare spring soils increasingly vulnerable to erosion and nutrient loss (Wolfe et al. 2018).

Interseeding cover crops in standing grain crops (primarily corn) have proven successful in warmer regions, like the Mid-Atlantic (Curran et al. 2018; Caswell et al. 2019). However, investigations of interseeding in vegetable crops suggest timing, species selection, and cover crop placement are all key variables for avoiding weed growth and water and nutrient competition in the system (Pfeiffer et al. 2015; Brainard and Bellinder 2004; Vanek et al. 2005). These are all variables that farmers consulted with have also faced in early attempts with this practice. Brainard et al. (2004)

and Vanek et al. (2005) showed that interseeding into mid-season cabbage and pumpkins, respectively, with legume cover crops 20 Days After Transplant (DAT) or later can generate cover crop biomass while avoiding crop yield loss. The data from these Michigan and New York-based projects will serve as a launching point for our outreach and the development of our research treatments focused on the Northern New England region.

Through a literature review and conversations with producers throughout Northern New England, we have identified the potential negative effects of improperly implementing this practice. In these conversations, growers have reported instances of crop competition, high levels of rodent damage, and yield loss. In all of these scenarios, we have attributed the loss to planting the cover crop too early in the season, a setback our project is poised to address. We also anticipate other unforeseen logistical setbacks of the practice, such as access to equipment for seeding, labor demands at seeding time, weed management etc. Our project is looking into these factors to develop regionally-specific recommendations to answer the following questions: 1) How does interseeding cover crops in late season cabbage and sweet corn affect crop productivity? 2) What planting methods work best to establish interseeded cover crops? 3) What planting dates (based on crop growth stage) optimize both cover crop biomass development and cash crop productivity in the Northeast? 4) What cover crop species are best suited for late-season establishment in our region? 5) What are the equipment, timing, labor and other barriers to establishing a cover crop in an established sweet corn or fall brassica crop in Northern New England?

Materials & Methods

This project includes two distinct experimental trials, referred to in the following sections as Trials A and B.

Trial A:

Late season plantings of sweet corn and fall cabbage are being tested in separate trials. Treatments are the same for both: (a) timing of seeding (main-plot treatment), and (b) seeding method (sub-plot treatment). Our timing treatment for cabbage includes planting a cover crop of annual ryegrass and crimson clover mixed (25 lb/A 60% ryegrass:40% clover), at 17, 23, and 30 DAT, (Aug. 12, 18, and 25, 2022 respectively) with an additional post-cabbage-harvest cover crop planting date (October 20, 2022) serving as a control. Our timing treatments for sweet corn included v3, v5, and v8, (August 3, 18, and 30, 2022 respectively) using a post-harvest cover crop planting date as our control (September 27, 2022). Within those treatments, we are testing the effects of different interseed planting methods in Trial A. While broadcasting seed is the easiest method for distributing cover crop seed, there is significant evidence that incorporation of the seed will significantly speed up germination and increase germination rate (Baker and Griffis, 2009; Barnett and Comeau, 1980; Brennan and Leap, 2014). Therefore, we will test; broadcasting seed, broadcasting and incorporation by cultivation at the time of seeding, and drilling the seed between crop rows with an Earthway® push seeder. We hypothesize that drilled seed will result in the optimal time for germination, cover crop stand density and long-term cover crop biomass.

Trial B:

There is minimal data available about what cover crop species will work best for this practice in northern New England. To address this question, Trial B is testing cover crop species planted in corn at the hypothesized optimal seeding time (v5). Species treatments will include oats and peas mixed (100lb/A 50%:50%), cereal (winter) rye and hairy vetch mixed (55lb rye, 25 lb vetch/A), and annual ryegrass and crimson clover mixed (25 lb/A 60% ryegrass:40% clover), and a control treatment (bare ground), all broadcasted and incorporated.

We are collecting data on soil nitrate, soil moisture, weed biomass, crop yields, and cover crop biomass.

Results

This research is still in progress and, as of this writing, the results collected from the first year are yet to be analyzed. Observationally, in the sweet corn timing trial A, our team saw excellent biomass and growth of the cover crop at V3 and v5. V7 plantings had thinner cover crop stands at the time of harvest and mowing (October 4th). In the cabbage timing trial A, the 17 DAT plots (seeded on August 12) appeared to have excessive cover crop growth, with an even distribution of flowering shepherds purse weeds throughout. While no significant disease was observed on any of the crops, the cover crop biomass was decreasing airflow and crowding the crop. Plots that were drilled or broadcasted and incorporated had fewer weeds and thicker cover crop biomass than broadcasted plots alone. We hypothesize that the very dry conditions during cover crop seeding had a significant influence on cover crop germination, ground cover, and biomass. However, no obvious differences in yields were observed.

a. b) c)

Images 1. a-c: Plant ground cover percentages by cover crop timing treatment (all broadcast incorporated) in Sweet Corn Timing Trial A. Images of coverage percentages captured through the *Canopeo App* on September 27th, 2022. *1a, V3 Seeding (66% Coverage): 1b, V5 Seeding (58% Coverage): 1c V7 Seeding (21% Coverage).*

Farmer collaborators had mixed impressions of the demonstration plots installed on their farms. In the cabbage plots, the density of planting had a significant influence on the ability of the cover crop to germinate. Tight plantings of 12” in-row, 12” between-row, and 3 rows per bed plantings were too tight to allow germination. Some coverage was obtained in the walk rows, which the growers appreciated for harvest traffic during the muddy fall, and soil erosion prevention down the rows. Wider spacings of 18” in-row and 24” between rows and 2 rows per bed allowed for better germination and biomass production, especially in the walk rows. In 2022, broadcasting

seed at the final cultivation proved efficient and very effective at the incorporation of cover crop seed and excellent management of weeds.

In fields with a history of herbicide use, one field showed very poor germination of winter rye. A neighboring field on the same farm, with a similar soil type, planted on the same date showed excellent winter rye germination, leading us to believe that herbicide carryover was responsible. We are diving into spray records to identify specific chemistries that may be responsible. In corn plots where cover crop seed (annual ryegrass and crimson clover 25lb/A) was broadcasted at last cultivation, or with the final dressing of nitrogen, the cover crop germinated and provided good cover. In one plot, neighboring bare soil rows showed rill erosion down the between-row zone, while interseeded plots (annual ryegrass and crimson clover 25lb/A) showed no sign of soil loss.

Our research will continue to analyze collected data and to work with growers on equipment and logistical approaches to this practice.

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High glucosinalate mustard for weed and disease control @4Corners Farm

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In 2014 4Corners Farm heard of implementing mustard as a cover crop and biofumigant from touring farms in Ohio and having heard in the industry other farms in Canada have begun planting mustard. After experimenting with Mustard here at the Farm in Newbury Vt we have used it , not only as a fast, low maintenance cover crop, but to improve soil conditions and better manage the land. Our interest peaked when we heard mustard was being grown to biofumigant the soil that ultimately leads to less reliance on synthetic pesticides as weed control.

The process of bio fumigation is the decomposition of plant materials or animal products that release volatile compounds that excrete bio pesticidal properties into the soil. Brassicas, such as mustard, contains organic compounds called glucosinolates. When the tissues of these plants are damaged, chopped and tilled they biologically active a chemical production. One of the most important compounds released in the process is isothiocyanate (ITC). When these compounds combine, they create the spicy component of the mustard that has a pungent smell. This gas can trapped in the soil and be used in combatting the growth of weeds without synthetic pesticides.

Having expanded our use of mustard crops we now have experimented with growing in the spring, summer and fall for cover crops. We discovered benefits for growing it throughout the season as a ground ready crop for easy field turn over.

In order to have the best success rate of your mustard plating you'll want to use a Brillian style seeder, on semi dry soil and follow closely the procedures for best fumigation. It's time to flail-mow the mustard when the 3rd and bottom flower on the plant has started to form a seed pod. Once the mustard is cut it's important to till in the plant matter within 20 minutes for the most potent fumigation. After the material is incorporated into the soil you'll want to roll or water with in 24 hours. Observe for two weeks to determine how successful the mustard was in mitigating the weed germination.

We will continue to use mustard for a cover crop as well as a biological pesticide treatment for the best soil maintenance. We plan to experiment with planting rows of mustard for trapping pests that other brassicas are subject to. If the pest could be attracted to the mustard perhaps, we can exterminate them before they infest our cash producing crops.

Advances in Broccoli Varieties

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The Eastern Broccoli Project brought considerable attention to the potential for expanding broccoli production in the East as well as the need for adapted varieties if that potential is to be realized. Both public and private breeders stepped up to address this gap. I will focus on varieties that have been identified as strong performers through our regional trial over the last 10 years, testing materials in up to fifteen environments each year.

The main adaptation needed for the East is to reduce the cool-temperature requirement for normal bud formation. That breeding process has been progressing for the last decade, and some improved varieties are on the market with others in the pipeline.

The midseason varieties mature in about 55 days from transplanting in the warm part of the growing season. The market-leading varieties are all of this maturity.

We consider three cuts to be normal. The exact timing depends on the economics of harvest. Usually, the first cut is small but high quality, the second gets the most yield, and the third has smaller heads that are sometimes bunched.

For most growers in our unpredictable climate, it pays to have several varieties planted. In steadier climates grower often have one variety for each slot through the season, but that is probably not the way to go in New England.

One of the big advances was **Eastern Crown**, from Sakata, albeit not from the Eastern Broccoli Project team. Sakata has been working on this adaptation because it is also important in Japan. Eastern Crown has dominated Eastern US acreage for the last five years or so. It is a very dense head for crown cut, and as a result it yields quite well. It has good tolerance to the summer heat, but will produce unmarketable heads following severe heat waves. It is a successor to Green Magic and Emerald Crown from the powerful Sakata breeding program.

Imperial is the Sakata variety with the greatest heat tolerance, and is used in the hot slot worldwide. Southeastern growers are using it going into the summer season. The head is quite low to the ground, so it takes a little more work to harvest. We have seen even Imperial come apart in summer trials, which shows how tough our conditions can be for international varieties.

Burney was an early introduction from Bejo and has been a reliable producer in adverse weather. It continues to have a good role in managing risk. Other varieties may be a bit prettier when conditions are prefect, but Burney is fully marketable and may well be the prettiest after heat spells.

Bejo **EXP3622.** This variety has better heat tolerance than Eastern Crown and a similar appearance. Developed by Bejo's Cees Sintinie with heat tolerance from Cornell's Philip Griffith. Some of our tasters thought it has more flavor. It had less Alternaria than the standards in recent disease trials, though we are awaiting the detailed report. For 2023, sample seed is available through the regional Bejo representative at no cost. A good grower response will result in more seed production and addition to seed catalogs.

Roxanne has done well in our southern Maine trials and appears to avoid summer purpling. It comes from Emerald Seed.

Lieutenant from Seminis has been a standard in the regional trials for ten years and remains a reliable performer. It has the stem length to be a bunch type, though the tradeoff can be a lighter pack. This classic is keeping a spot in the Eastern market.

Monty from ISI in Italy tested well with Johnny's in the summer in sourthern Maine, but it has not been the Eastern Broccoli Project so I have no comparative information.

A USDA developed hybrid, **BH055**, is tremendous for an early crop that can be first on the market or in a slot between other vegetables. This hybrid has great heat tolerance and matures with Castle Dome, about 9 days before the standards. It was sometimes as fast as 38 days. Because of the fast maturity, the heads are lighter than mid-season varieties and plantings should be harvested every other day in the heat of summer. It has uniform enough to be a two-cut variety. We are encouraging seed companies to produce this hybrid since it has a unique slot.

There are several more public-sector hybrids from USDA and Cornell that have better adaptation to the East, and they are need to find a seed-company partner to produce and market seed for Eastern growers. Unfortunately, companies with the capacity to maintain a broccoli variety also find Eastern North America too small a market to justify the investment.

For the crown-cut market in the New England summer, these new varieties provide opportunity to get broccoli customers earlier in the season and then have them be there when the bigger fall crop comes on. The varieties are all bred for a crown cut, because that is really the wholesale market today.

Only one seed company produces and markets organic broccoli seed today, Bejo. They recently added organic Burney seed, which is the choice for summer among their organic varieties.

The concentration on crown cut in the wholesale market opens opportunities for distinctive non-crown types for direct marketing. Various kinds of long-stem broccoli and sprouting broccoli are on the market. It will be difficult to compete directly with Sibsy from California in the broccolini category. One interesting new version makes a big head with long branches that can be harvested in one cut to make ten or more stems. **Monflor** from Syngenta and **Montebello** from Bejo are good examples. There are more that are crosses with gai lan producing good flavors for small bunches. Many varieties work well. Purple sprouting broccoli has also made an appearance. This heritage type (grown for centuries in southern Italy) looks good but has rather low yields on a big plant. Especially varieties that are late to mature. It is good to plan accordingly.

The old open-pollinated varieties from a century ago, DeCicco and Waltham 29 are really not competitive. They are at best small, variable and low yielding. A century of dedication to better broccoli really shows.

Overcoming the challenges of cauliflower production

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"Cauliflower will make a liar out of anyone." – told to me by an old cauliflower grower in Holland when asked for recommendations on which variety to grow.

While kale and cabbage are relatively easy to grow, while other Brassicas, like Cauliflower, Broccoli and Brussels Sprouts, can be more challenging. The leaves of kale, cabbage and similar crops represent vegetative structures, while the heads of cauliflower and broccoli are generative structures. In other words, we grow these plants to produce flower buds, but we don't want these buds to continue growing into actual flowers. The plant will have other ideas! The successful production of cauliflower and broccoli therefore depends on the careful management of vegetative plant growth, crop planning and harvest timing, and matching cultivars and varieties to local growing conditions. Weather is unpredictable in the Northeast, and this makes cauliflower production unpredictable as well.

Grow a strong plant first

A strong plant with long leaves will be able to provide enough cover to protect the developing head. A small plant with small leaves, on the other hand, will leave any developing heads exposed to direct sunlight and heat. This will cause problems with fuzziness, loose curd (riciness), leaf in head, purpling, etc.

Vernalization and flower development

Cauliflower is grown around the world, but each climate uses its own type of cauliflower. The type of cauliflower will depend on the amount of cold weather that is needed to trigger flowering (vernalization).

- Tropical cauliflower needs constant high temperature, no vernalization requirement
- Summer cauliflower has a low vernalization requirement and will flower in warmer weather
- Fall cauliflower will flower when days and nights get cooler (in fall)
- Winter cauliflower has a high vernalization requirement and will flower only after long exposure to cold weather (but not frost!!)

Avoid stress

Easier said than done! But it just is easier to grow a large, strong plant when there is adequate fertility, even soil moisture, and not too much heat stress. Fertility and soil moisture can be managed with cover crops and a variety of nutrient sources (manure, dry fertilizer, etc.) and irrigation.

Use irrigation during the hottest and driest growing periods to make sure that the wrapper leaves stay healthy and keep growing. Without enough moisture these leaves will develop **tipburn**, and in severe cases the wrapper leaves will not develop at all and this will leave the developing head exposed to the elements.

Avoid heat stress by growing cauliflower only in late summer and fall, or by switching to **varieties with better heat tolerance** and lower vernalization requirements. (see above)

Protect the developing heads by **tying** the wrapper leaves around the head to protect it from the light and heat. Wrapping the head is also known as "blanching" and prevents yellowing/greening and loss of quality due to heat stress. Some of the newer varieties are sometimes called "self blanching" because the wrapper leaves are well-developed and form a tight cover around the head. These varieties do not need to be tied if you are going to harvest smaller cauliflower, but some tying might still be needed when a larger head is desired.

Diseases and pests

Cauliflower is susceptible to the normal Brassica pests and diseases, but these are fairly common and can be managed with the typical fungicides and insecticides, exclusion netting and good cultural practices. The only disease that can be frustrating to manage is **Alternaria brassicae** (Dark leaf spot). This disease can cause brown lesions on the leaves, but can also infect the developing head. Once the head is tied and the wrapper leaves seal in the humidity around the head the fungus can quickly form a **mass of sooty black spores**, ruining the appearance of the head. Keep the disease under control and give the plants a chance to dry up before tying.

Variety Selection

Consider your growing conditions and your markets. Do you have a good market in summer, or is the market better in the fall? Growing in summer is riskier, growing in cooler fall temperatures is easier – but there will be more cauliflower on the local market. Would you like to harvest all your cauliflower at once (uniform harvest maturity), or are you happy to harvest multiple times and spread out the harvest?

For **summer** production choose quick-growing varieties with good uniformity of harvest, such as CANDID CHARM, STEADY and BERMEO.
Varieties that need just a bit more cold weather to flower well (warm days OK, but with cooler nights) include ALCALA, FLAMENCO, FREEDOM, MINUTEMAN, TWISTER, and others. These varieties also work well in **early fall**.
For **fall and late fall** production look to varieties like ADONA, TOLEDO, ALTAMIRA, and SKYWALKER.

There are also overwintering varieties, but these are only planted in areas where winters are mild with no or very little frost, such as Brittany and Normandy in France. You could think of similar climates around Vancouver or Coastal Washington, or some areas in the mid Atlantic, perhaps. These varieties still need to be planted in summer – they take a long time to grow and need lots of cold weather exposure to trigger head formation. Then you have to dress warmly for harvest and "hunt" for plants with mature heads. Then you have to ask yourself: do you really want to take care of this crop for 200+ days and risk losing it all to a freak frost, anyway?

Managing Brassica Foliar Diseases

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Alternaria leaf spot (ALS) and downy mildew (DM) are two of the most common fungal foliar diseases of brassica crops, both of which also cause head rot. ALS is caused by *Alternaria brassicola* and is specific to brassica/crucifer/Cole crops including broccoli, cabbage, cauliflower, Brussels sprouts, kale, etc. and weeds (e.g. mustards such as Shepherd's purse and field pennycress). It can survive in soil and crop debris and can be spread onto plants from splashing soil and over longer distances aerially. Optimum temperatures for ALS are 75° to 82°F, and when leaf wetness is prolonged for 20 hours of more, ALS can produce many spores outside of the optimum range of temperatures. DM is similar to ALS in its survival, spread and requirement for leaf wetness, but its optimum temperature range is 50 to 60 °F. Disease risk tends to be highest in August and September as heavy dew and remnants of hurricanes usually result in favorable conditions for both ALS and DM.

Fungicide Recommendations for ALS in Broccoli, 2022

Cornell Fungicide "Cheat Sheet" sheet provides a list of fungicides that are labeled in broccoli and other common Cole crops, for which Cornell research has shown to be effective for control of Alternaria leaf spot (ALS) and head rot. The relative control of ALS was based on results from: 1) On-farm trial conducted under severe ALS pressure (Hoepting, 2018); 2) Conventional and organic fungicide trials (1 of each) conducted at Agri-Tech research farm under severs ALS pressure (Smart *et. al*, 2021); 3) On-farm trial conducted under low ALS pressure (Hoepting *et. al*., 2021); and 4) Conventional trial conducted at Agri-Tech research station under moderate-severe ALS pressure (Hoepting, 2021).

- Spray fungicides preventatively before disease establishes itself, because the leaves serve as inoculum to infect heads. This is especially important when disease is present in the area/planting and when conditions are favorable for disease (e.g. leaf canopy is wet from rain, irrigation or dew for prolonged periods (20 h or more), especially when temperatures are 75-82 ºF).
    - Bravo would be an economical choice at this timing.
- Once the canopy fills in, aeration is reduced and leaf wetness is prolonged. Begin application of systemic/translaminar fungicides with very good to excellent activity on ALS at this time, through head formation and harvest, especially when risk for disease is high.
- All fungicides listed in the Cheat Sheet except Bravo (FRAC M5) and copper (FRAC M1), are at risk of ALS developing resistance.
    - See ALS Fungicide Cheat Sheet/labels for rotation restrictions and seasonal maximum use rates.
    - Be mindful of pre-mixes that have more than one FRAC group per fungicide that need to be managed for fungicide resistance. For example, there are a few products of

FRAC 3 and 7 that are pre-mixes with FRAC 11, which makes it easy to apply 3-4 consecutive applications of FRAC 11 when rotating FRAC 3 with FRAC 7.

- For best fungicide resistance management practices:
  - Do not apply more than 1-2 applications before alternating to another FRAC group.
  - Do not use more than 2 applications per FRAC group per crop. Bravo and copper are the exceptions to this and may be used several times, because their multi-site mode of actions reduce their risk for fungicide resistance.
- Use the highest labeled rates, especially for Quadris and when conditions are favorable for disease.
- Use a 7-day spray interval when disease pressure is high, especially for organic products.
- Use an adjuvant with fungicides that have translaminar or systemic activity (FRAC 3, 7, 9, 11, 12) for improved efficacy. Read labels for details.
  - Be careful using adjuvants with copper bactericide or sanitizers, as excessive leaf burn injury may occur, especially with oil adjuvants when temperatures are >90 ºF.
- Save products with 0 (Endura, Quadris, Luna Sensation, organic products), 1 (Quadris Top) or 3 days (Priaxor) PHI for close to and during harvest.
- Note that Luna Experience, Endura, Miravis Prime, Inspire Super/Vango ESQ, Switch/Alterity and Oso 5%SC have no activity on downy mildew (DM).
  - ALS fungicides with good DM activity include Bravo, those with FRAC 11 (Quadris, Quadris Top, Priaxor, Luna Sensation) and FRAC P07 (Viathon).
  - Best control of DM is provided by Orondis Opti/Ultra, Revus and Presidio. Note that these fungicides do not have activity on ALS.
- **Do your fungicide spray program "puzzle" ahead of time.** Although there are a lot of fungicide options, it can be tricky to not exceed 2 apps per FRAC per crop, especially when so many products contain premixes of two FRAC groups (e.g. Luna Sensation contains FRAC 7 and 11). It is a good idea to design a 4-6 week program to use from full canopy fill through harvest. Prior to this, Bravo should suffice. Start with the products that you want to use during harvest with 0 PHI and work backwards to avoid no more than 2 apps per FRAC.

Example Fungicide Spray Program for Alternaria Leaf Spot and Head Rot in Brassicas.

Week	Crop Stage	Product and Rate/A	FRAC Group	PHI	Disease Control	
					ALS	DM
1 & 2	1-2 weeks after transplants, prior to ALS detection	Bravo Weatherstik 1.5 pt	M5	7	Mediocre	Good
3	Pre-heading, large canopy	Inspire Super 20 fl oz	3 + 9	7	Excellent	None*
4	Heading begins	Miravis Prime 11.4 fl oz	7 + 12	7	Excellent	None
5	Harvest begins	Quadris Top 14 fl oz	3 + 11	1	Excellent	Not Labeled
6	During harvest	Luna Sensation 7.6 fl oz	7 + 11	0	Excellent	Mediocre

*If DM is at risk, then add Bravo or other fungicide with activity on DM to tank mix.

Fungicide trials in 2021 were partially funded by a grant from the United States Department of Agriculture's National Institute of Food and Agriculture through the Specialty Crops Research Initiative (USDA-NIFA-SCRI), award number 2020-51181-32062.

Cornell Fungicide "Cheat Sheet" for Alternaria Leaf Spot and Head Rot in Broccoli and Other Cole Crops, 2022

Product and Rate/A	Active Ingredient	FRAC[1] Group	Risk of Fungicide Resistance	PHI (days)	Maximum Use		Rotation Restrictions[2]	Cole Crops on Label[3]	Disease Control	
					Rate/A	No. apps			ALS[4]	DM[4]
Bravo Weather Stik 1.5 pt*	chlorothalonil	M5	Very low	**7**	11.7 pts	7	none	ALL	Mediocre	Good
Quadris 6-**15.5** fl oz*	azoxystrobin	11	High	**0**	90 fl oz	5-15	none	ALL	Good	Mediocre
Switch 10-14 oz **Alternity** 11-14 oz*	cyprodinil + fludioxonil	9 12	Medium	**7**	56 oz	4-5	2	ALL	Good	None
Priaxor 6-8.2 fl oz	fluxapyroxad + pyraclostrobin	7 11	Medium-High High	**3**	24.6 fl oz	3	2	ALL	Excellent	Mediocre
Endura 6-9 oz	boscalid	7	Medium-High	**0**	18 fl oz	2	2	ALL	Very Good	None
Luna Experience 6-8.6 fl oz	fluopyram + tebuconazole	7 3	Medium-High Medium	**7**	34 fl oz	4	2	**Brassica leafy greens only**	Excellent	None
Luna Sensation 5-7.6 fl oz	fluopyram + trifloxystrobin	7 11	Medium-High High	**0**	15.3 fl oz	2	2	ALL	Excellent	Mediocre
Miravis Prime 11.4 fl oz	pydiflumetofen + fludioxonil	7 12	Medium-High Low-Medium	**7**	34.2 fl oz	3	2	ALL	Excellent	None
Inspire Super 16-20 fl oz **Vango Esq** 14-20 fl oz*	cyprodinil + difenoconazole	9 3	Medium Medium	**7**	80 fl oz	4	2	ALL	Excellent	None
Quadris Top 12-14 fl oz	azoxystrobin + difenoconazole	11 3	High Medium	**1**	56 fl oz	4	1	ALL	Excellent	Not Labeled
Viathon 2 pt	tebuconazole + potassium phosphite	3 P07	Medium Low	**7**	8 pt	4	none	**Brassica leafy greens only**	Good	Good
Topguard 5-8 fl oz	Flutriafol + azoxystrobin	3 11	Medium High	**7**	32 fl oz	4	Rotation recommended	ALL	Very Good	Not Labeled
Cevya 3-**5 fl oz**	mefentrifluconazole	3	Medium-High	**0**	15 fl oz	3	2	ALL	Good-Poor	None
Oso 5%SC 6.5-13 fl oz	Polyoxin D zinc salt	19	Medium	**0**	78 fl oz	6	none	ALL	Good – Very Good**	None
Kocide 3000-O 0.5-**0.75 lb**[5]	Copper hydroxide	M1	Low	**0**	8.8 lb	11	none	ALL	Mediocre-Poor	Labeled**
Carb-O-Nator 2.5-5 lb/100 gal	Potassium hydroxide	Not Classified	None	**0**	none	none	none	ALL	Poor	Labeled**

***And other labeled formulations,** such as Aframe is a generic version of Quadris. There are several formulations of Bravo products. **Vango ESQ** is a generic version of Inspire Super and **Alterity** is a generic of Switch.

[1]**FRAC: F**ungicide **R**esistance **A**ction **C**ommittee group. Fungicides that belong to the same FRAC group are at risk for developing cross-resistance. For best fungicide resistance management practices, fungicides belonging to different FRAC groups should be rotated.

[2]**Rotation Restrictions:** No. of consecutive applications allowed before must rotate to a different FRAC group.

[3]**ALL Cole crops** includes broccoli, cabbage, cauliflower and Brussels sprouts. Often, kale, collards, kohlrabi and mustard greens also on label (see labels for details). **Luna Experience** and **Viathon** are only labeled on Brassica leafy greens such as broccoli raab, Chinese cabbage (Bok Choy), collards, mizuna, etc. NOT broccoli, cauliflower or cabbage (see label).

[4]**ALS: Alternaria leaf spot and head rot.** Relative disease control based on 2018 (1 on-farm) and 2021 (2 conventional & 1 organic at Cornell Agri-Tech, 1 on-farm) fungicide trials (Smart *et. al.* 2021, Hoepting 2018, 2021). **DM: downy mildew.** Best control of DM is provided by Orondis Opti/Ultra, Revus and Presidio. **Kocide 3000-O and Carb-O-Nator are labeled for DM, but Cornell has NOT trialed these products on DM.

[5]It is likely that other copper-based products have activity on Alternaria diseases of Cole Cops, but Kocide 3000-O is the only one that we have data on at this time.

See CCE Cornell Vegetable Program website for current version of Cheat Sheet: https://cvp.cce.cornell.edu/

Growing Early Snap Peas in High Tunnels

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This presentation will cover transplanting snap peas for early production in high tunnels. We will cover the seeding process and transplants vs. direct seeding. We plant densely to maximize the planting and yields and do 2 successions for transplants along with some direct seeding which acts as a 3rd succession. Typically we seed from the beginning of March to mid-March and plant out towards the end of March. We will cover the varieties that we have used over the years, but our favorite is Super Sugar Snap and Sugar Snap for longer production time. We will also cover trellising with HortaNova and stringing. It is a super crop to have on your market tables early in the season, or for your CSA members. We typically harvest snap peas towards the end of May for our area.

Why Mushrooms?

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Mushrooms are definitely having a moment-in fact they have been for the past couple of decades. In the past, mushrooms were mostly been known for what they don't have: many calories, much fat, no cholesterol, much sodium, and no gluten. In recent years, word has gotten out that in addition to being delicious, mushrooms provide us with nutritional compounds that are missing or scarce from other items in the produce aisle including ergothioneine (and by extension glutathione), phosphatidylserine, and thousands of unique fungal polysaccharides, terpenes, sterols and phenols. Mushrooms are the only source of vitamin D in the produce aisle and are a good source of potassium, selenium, copper, riboflavin, niacin, and pantothenic acid (https://www.mushroomcouncil.com/nutrition/benefits-nutrients/).

According to the most recent NASS/USDA statistics, year over year specialty mushroom sales are showing strong growth-up 32% from 2020-2021 to 2021-2022 with an average price increase over the same period of 67 cents per pound. *Agaricus* sales went down 8% in the same time period, while price per pound also increased by an average of 67 cents per pound (https://www.nass.usda.gov/Publications/Todays_Reports/reports/mush0822.pdf). *Agaricus* still dominates the US market at more than 26 times the sales of specialty mushrooms (roughly 616 million vs 24 million), but I predict that the specialty mushroom market will continue to enjoy a healthy rate of expansion in the coming years. Pennsylvania dominates mushroom production, producing 66% of all mushrooms grown in the US, followed by California which produces about 11% of the nation's mushrooms.

Mushrooms can be grown in all sorts of situations with an almost infinite combination of a variety of mushroom types, substrates, structures, environments, and techniques. Once one has a basic understanding of what mushrooms need to grow, there is no reason why anyone who wants to grow mushrooms should not do so. Cultivated mushrooms can be divided into three basic categories: soil inhabiting, wood inhabiting, and plant pathogens (and of course some mushrooms cross categories). Cultivation techniques are commonly categorized by full cultivation, half-cultivation, indoor cultivation and outdoor cultivation and every combination of those categories. Potential growers need to consider, among other things: what their intended market is, what raw materials they have available consistently, how they will prepare their substrates for inoculation, sources of inoculant, what buildings and environmental control they have or need, (i.e. heating, cooling, CO2/O2, lighting, air flow and exchange, humidity, etc.), water supply, proximity to sinks of pests and diseases, pest and disease control (pre-crop, cropping, post crop), the need for cold storage, transportation, etc. Cultivated mushrooms can also act as a 'canary in the coal mine' so it is important to be aware of possible petroleum and other chemical contamination in proximity to your facility to avoid mutations and crop failures.

Basic mushroom cultivation can be summarized into four steps (courtesy of John Donaghue of Northwest Mycological Consultants):

1. Create a nutrient source (substrate) that is selective for your mushroom.
2. Inoculate the substrate with your fungus so that it will dominate.
3. Manage the environment to favor growth and nutrient utilization.
4. Foster periodic mushroom initiation and development.

Within each one of those steps are opportunities to adapt to your desire to grow mushrooms and the resources you have available. Within each one of those steps also is the potential for a successful crop or a spectacular failure. But why not? What have you got to lose? Get out there and grow some mushrooms!

PFAS Contamination and Vegetable Farming

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Recent detection of per and polyfluoroalkyl substances (PFAS) in water and soil use for agricultural production has led to focused concern, response, and remediation in New England states.

This class of chemicals includes perfluorooctanoic acid (PFOA) and perflourooctanesulfonate (PFOS) which have been used widely since the 1950's in a range of products such as non-stick cookware, stain resistant carpets and furniture, water-resistant clothing, coated oil resistant paper and cardboard food packaging and personal care products. PFAS chemicals become a potential hazard to agriculture and food production since they are widespread and persistent in the environment in air, water, and soil. Sometimes, waste products from manufacturing processes and household uses involving PFAS chemicals have been spread as biosolids or ash on farmland.

The health impacts of PFAS are still being studied for better understanding. However, these chemicals may affect cholesterol levels, thyroid function, birth weight, liver function, infant development, the immune system, and may increase the risk of some cancers including prostate, kidney, and testicular cancers.

This session will focus on our current understanding of PFAS in vegetable production. It will include the perspectives of a technical service provider and educator working with organic farmers in Maine and also a Maine farmer impacted directly by contamination on their farm.

Lessons from a PFAS Impacted Maine Farm

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Songbird Farm was a 30-acre, diversified organic farm producing vegetables and grain products for local wholesale and direct market / CSA customers. Johanna Davis and Adam Nordell ran the farm from 2010 until the winter of 2021, when they discovered catastrophically high industrial chemical contamination in their soil and irrigation water. The chemicals arrived on their farm 30 years earlier, through the spreading of municipal water treatment sludge (aka biosolids). The chemicals were detected in some - but not all - of the farm products. The discovery launched Davis and Nordell into an advocacy roll alongside 4 other PFAS impacted farms in central Maine. The collective testimony from this group helped advance a more precautionary approach towards the disposal of sludge and build a framework for a PFAS farm safety net in Maine and federally. Songbird Farm remains out of production.

For more information:
MOFGA PFAS Resources - https://www.mofga.org/pfas/
Maine Department of Agriculture, Conservation, and Forestry PFAS Page - https://www.maine.gov/dacf/ag/pfas/index.shtml

Farm Postharvest Case Studies

Pheonix and Megan O'Brien
Hall Brook Farm
34 Berry Rd, Thorndike, ME 04986

Elizabeth Keen
Indian Line Farm
57 Jug End Rd, Great Barrington, MA 01230

Kate Donald and Amber Wilson
Stout Oak Farm
83 Middle Rd., Brentwood, NH 03833

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Postharvest handling and storage are critical steps in the farm production system, but often is one of the last things to get attention. Many farms make do with whatever they can for quite some time before investing in a renovation of an existing building or building something new.

In this panel discussion three farms with varied crops, scale, and markets will discuss recent postharvest construction projects.

Hall Brook Farm – Hall Brook Farm is a 100 acre farm located in beautiful Thorndike, Maine. We raise mixed vegetables which we sell wholesale to health food and grocery stores from Bangor to Scarborough. New construction of a metal building with radiant slab floor in support of a medium scale wholesale focused farm with year-round marketing. The building includes a loading dock and grade level loading with large overhead doors, wide open floor plan offering flexibility for equipment placement, flexible electrical supply connections, bathroom with future shower area for crew, a single pack-out cooler. This project involved significant contractor, supply chain, and schedule challenges.

Indian Line Farm – Indian Line Farm grows on 17 acres in Great Barrington, Massachusetts supporting a medium scale Community Supported Agriculture (CSA) operation. Indian Line Farm is now known as one of the first (CSA) farms in the United States, and was established in 1985 by Robyn Van En, Jan Vander Tuin, and a coalition of local citizens. This project was a major renovation of a repurposed bank barn historically used for dairy production. Work included significant structural improvement, raising the bottom floor ceiling height, pouring a new concrete slab, new water line, new drainage, new coolers, heat pump heating and cooling and lots of light.

Stout Oak Farm – Stout Oak Farm grows 5 acres of Certified Organic vegetables for their Farm Store, CSA shares, farmers' markets, and wholesale accounts in Brentwood, New Hampshire. The farm has been working out of a seasonal, temporary wash/pack arrangement for years. This year they built a 3 season open-air pavilion offering a more permanent space. This project involved a poured slab, a pole barn kit with steel trusses, open floor plan, everything on wheels, lots of white boards for team communication and organization, and "living in" before "settling in".

For more information:
https://go.uvm.edu/hallbrook
https://go.uvm.edu/indianline
https://go.uvm.edu/stoutoak
For more postharvest case studies visit: https://go.uvm.edu/phcs

State Produce Safety Improvement Programs

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Several states in New England have developed programs that provide financial and technical support of farms pursuing projects that will improve produce safety and market access. In this session we will hear from three of them.

For more information:
Massachusetts Commonwealth Quality Program - https://www.mass.gov/service-details/commonwealth-quality-program-cqp
Vermont Produce Safety Improvement Grants - https://agriculture.vermont.gov/food-safety/produce-program/produce-safety-improvement-grants
Maine Produce Safety Improvement Grants - https://www.mofga.org/maine-produce-safety-improvement-grant/

Growing Kiwiberries in New England: A Grower's Perspective

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Background: Clover Nook Farm is an 8th generation family farm with roots dating back to 1765. Our main goal is to provide the community with the highest quality fresh fruits, vegetables, and meats while utilizing sustainable farming practices and minimal pesticide use. We grow a wide variety of annual vegetable crops along with a small herd of beef cattle. In total, our farm is 90 acres (about 60 acres tillable). All of our produce is sold retail through our farm store and farmers markets.

Why Kiwiberries? I was first introduced to kiwiberries as an undergraduate at Cornell University at the Cornell Orchard during one of my horticulture classes. I had never heard of them before and thought they were delicious. My family's farm was not yet growing any perennial crops, so I did not pay much attention to the idea of growing them at the time. Fast forward a few years after graduating, and I am back on the farm looking for new crops to grow. I had learned that being a small retail farm that it was important to grow niche varieties and crops to set ourselves apart from mainstream grocery stores. I decided it was more important to focus on these niche crops and buy in most of your staple crops such as cucumbers, squash, etc since they are generally readily available to purchase wholesale.

I had wanted to get into growing a perennial crop, particularly some sort of berry because we have a longtime relationship with a nearby orchard that provides all the tree fruit we need, and there is no need to compete with them since they do an outstanding job. As I looked into what sort of berry crop to grow, SWD kept coming up as a recurring concern getting into any sort of berry crop, as there is still not a good solution to the pest. Eventually I had remembered the kiwiberries I had while an undergrad, so I started reaching out to some contacts at Cornell who eventually led me to Dr. Iago Hale at University of New Hampshire who was doing extensive research and outreach of kiwiberries in New England. After doing a fair amount of research, they seemed like a good fit for my farm. They currently have no pests and require no spraying of any kind. Birds are also not an issue, so there is no need for bird netting. The main input is the winter prune, which fit well for our operation as it adds a winter task to keep more of my employees working year round. I also liked the ability to store them long term in cold storage. I then attended one of the fall field day workshops at UNH to learn more and see the plants first person, and decided to move forward with planting them on my farm.

Growing experience: In 2019, I had selected a small area on my farm (approx 0.4 acres) to plant my kiwiberry vines. I purchased 1 year old vines from Hartmann's supply out of Michigan. A total of 75 vines, I have 30 Geneva females, 30 Anna females, and 15 Meader Male vines.

The trellis and initial establishment was a significant investment of both time and money. Weed control was difficult at first until I started mulching the rows with wood chips. After trellis construction and planting, they were fairly low maintenance the first growing season as they got established and selected a leader vine to be the main trunk for years to come.
The second year of growing (2020) was again fairly low maintenance since the trellis was already constructed. This year was again vine establishment, trying t get a leader vine to the top of the trellis and continue to get the vine architecture to the right point as they reached maturity to begin fruiting.

In the third year (2021) I was surprised to have some of the vines flower in the spring. About half of the females and only 3 of the males flowered, but they still yielded a marketable crop. Dr. Hale was also surprised that my vines had begun fruiting this early on. That winter was our first major winter prune since establishing the vines, and it was quite a job. Each vine takes 1-1.5 hours for one person to prune.

This past year I had all of my vines mature enough and have the correct architecture to yield my first major crop. Again, compared to other crops kiwiberries are pretty low maintenance in the growing season. The major time input is without a doubt the winter prune. Harvest would be the next major time input, but isn't too bad. After growing mostly annual vegetables, it is nice to have a crop where we can pick them standing upright. I had such a large harvest that I also began wholesaling through several different options. I anticipate the next few years to have even higher yield potential as the vines are still not fully mature and utilizing the entire trellis.

Customer Reception & Sales: One of the main reasons I went with kiwiberries is because while they are a niche crop, they are not too far away from a fruit most people are familiar with – the fuzzy kiwi. Because of this connection to a familiar crop, most customers are intrigued and willing to try them. Kiwiberries are packed into half pint (6oz) clamshells and sold for $3.99/ea currently.

One of the learning curves I have had to overcome is learning how to effectively ripen the berries and have them ready to eat when they hit the shelf. Since it is a new crop, I knew that if a customer eats an unripe one they will be unlikely to purchase them again in the future. That is why it was critical to learn the ripening process to offer ripe fruit only. Additionally, having ripe samples to teach customers what a ripe fruit looks and feels like is truly a must with kiwiberries. Roughly 70% of customers that tried a sample ended up purchasing a package. Once people have gotten a taste of kiwiberries, they often become repeat customers. During the second year of harvest, some customers who had already had them previously were purchasing multiple packages from the get go. I also found that once customers are hooked, they spread the word to their friends/ family and we gain additional sales and interest that way.

Total sales for the small 2021 kiwiberry crop was $1,819.69 which was all sold retail through our farm store and farmers market. This past crop, retail sales were $3,463.82 and wholesale $2,067, totaling $5,530.82 for 2022. As of writing these proceedings I have not crunched the numbers yet, but I believe this year we will be in the black on the kiwiberry investment. Kiwiberries are unlikely going to be the most profitable crop of your farm, but they add a good niche fruit option for your customers and are fairly low maintenance during the busiest time of the year on a

diversified produce farm. This year it was clearly observed that customers became more aware of the product and will look forward to it next year. Yield potential will definitely continue to increase the next 2-3 years as the vines still have a good amount of establishment still to do.

Small Scale Processing Opportunities

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For many specialty small fruits, the perishability of the fruit makes them ideal candidates for use in processed products. However, just like different species of fruit have different nuances depending on the variety, different value-added foods have their own set of challenges depending on the process and product. This session will describe some basic points of product development, food safety hazards, and an overview of key regulatory requirements to provide a broad overview of the food safety consideration needs of small and emerging value-added farm businesses. Attendees will increase their knowledge of food safety principles to enable success in the marketplace. The discussion will include berry-specific examples to share potential approaches for applications for berries (including honeyberry, kiwi berry, and elderberry). Topics include defining the difference between retail vs. wholesale processing; residential vs commercial kitchens (and co-packing); processed food regulations: canning vs jelly/jam vs. juice vs freezing vs. other processes and share a variety of resources that can help new product developers start the process to deliver value-added foods.

Available resources:

- https://ag.umass.edu/value-added-food
- https://ag.umass.edu/food-science
- https://www.mass.gov/forms/the-massachusetts-food-processors-resource-guide
- https://pchf.necafs.org/ Home | Processors' Food Safety Toolkit

Colorado Potato Beetle Management: Problems, Solutions, and Perspectives

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Colorado potato beetle, *Leptinotarsa decemlineata* Say, is the most important insect defoliator of potatoes in the Northeastern United States that can be readily recognized by pretty much every potato farmer in this area. These beetles have been damaging potato crops for over 170 years, during which they had also spread throughout most (although not all) major potato-growing areas of the world. In the absence of adequate control, Colorado potato beetles can completely destroy potato vines and reduce harvestable tuber yield pretty much to zero.

Ever since the Colorado potato beetles switched from their wild hosts in the family Solanaceae, farmers were looking for ways to control them. Many of the early attempts to develop chemical insecticides were directed against this pest, and it remains an important target for the research and development arm of the pesticide industry. Evaluating the success of these efforts is somewhat of a philosophical undertaking, along the lines of the famous "glass half-empty vs glass half-full" dichotomy. On the one hand, potato farming has largely remained an economically sustainable enterprise, in part thanks to successful Colorado potato beetle control by synthetic insecticides. On the other hand, the beetle remains to be a clear and present danger to potato growers. Success of each insecticide has proven to be fleeting, and constant development of new compounds was required to keep up with the emergence of insecticide-resistant beetle strains.

Impressive propensity of the Colorado potato beetle to evolve insecticide resistance is likely due to a confluence of several factors. First, even before being exposed to the first synthetic insecticide, the beetles had evolved an ability to survive the toxins naturally produced by their host plants. Secondly, the beetles are very prolific; therefore, a single resistant mutant can produce a lot of resistant offspring. Thirdly, they have a diverse and flexible life history that allows at least some part of a given population to survive unfavorable environments.

For almost 25 years, Colorado potato beetles have been successfully suppressed by neonicotinoid insecticides on conventional farms and by spinosad on organic farms. However, currently there is a widespread resistance to both classes of chemicals. Furthermore, neonicotinoids are scrutinized because of non-target effects on bees and other pollinators. Therefore, there is a need to look for alternative approaches.

Using chemicals is not the only approach to reducing Colorado potato beetle damage. Colorado potato beetles have a limited range of host plants in a single botanical family Solanaceae. Consequently, rotating potato fields to pretty much any crop that is not a tomato or an eggplant has been repeatedly demonstrated to reduce beetle populations. Unfortunately, vacant farmland is not exactly overabundant in the Northeastern United States, while hungry beetles can fly over significant distances. As a result, crop rotation cannot by itself guarantee successful protection of potato crops.

Biological control has been commonly suggested as a safe alternative to chemical control. Colorado potato beetles are attacked by a number of predators and parasites. However, the beetles have high reproductive rates, with an average female laying about 600 eggs. Therefore, natural enemies usually cannot keep up with the growth of Colorado potato beetle populations and prevent them from causing economically significant damage.

These challenges necessitate continuous reliance on insecticides for protecting potato crops, which is impossible without developing new active ingredients to replace older chemistries that are either failing due to insecticide resistance or become unavailable for purchase due to concerns about their effects on the environment. RNA interference, commonly abbreviated as RNAi, is a new technology that allows designing biorational insecticides that are highly specific to the species of their target pests. Unlike other insecticides that normally target specific proteins within insect bodies, RNAi-based products prevent such proteins from being synthesized on the first place by targeting information transfer from DNA via messenger RNA.

RNAi-based insecticides will not provide a silver-bullet solution to the challenges of Colorado potato beetle control. To the contrary, their extensive use is likely to result in insecticide resistance in beetle populations similar to that developed to other chemistries in the past. However, they provide a valuable option for integration with other active ingredients and with crop rotation. Furthermore, being specific to the genes found in the Colorado potato beetle, they are likely to have little or no effect on natural enemies.

Managing Potato Diseases, from Seed to Field

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Potatoes are affected by many diseases, some of which come in with the seed tubers while others originate in the field or are blown in from other farms or regions. Pathogens present on harvested tubers can also led to rot in storage, so identifying them before or during harvest can help to prevent additional post-harvest losses. A few common diseases/disorders to be familiar with include Rhizoctonia stem canker and black scurf, common scab, black dot, and periderm disorder syndrome (aka pink eye). Ear are described further below.

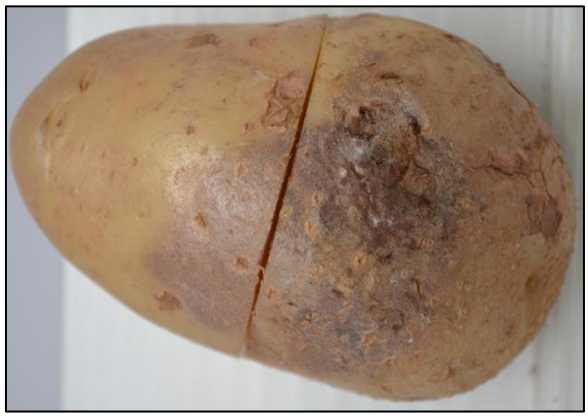
Rhizoctonia stem canker and black scurf are caused by *Rhizoctonia solani*. Although *R. solani* is a common soilborne pathogen in vegetable production systems, it is divided into a number of subgroups called anastomosis groups (AGs) based on the ability of isolates to fuse hyphae (anastomose) with one another. AG-3 is the most common group infecting potatoes. Other anastomosis groups are rarely thought to be damaging to potato. The phase of the disease called black scurf is common on potato tubers. Irregular black to brown hard masses called sclerotia develop on the surface of the potato. Although these structures superficially adhere to the surface and do not cause any direct damage, they are a primary means of dispersing the pathogen on infected potato seed. The sclerotia are also capable of overwintering as well as surviving in the soil for several years. The most damaging phase of the disease occurs when the pathogen infects the stems and stolons before they emerge from the soil. Depending on the size of the lesion that develops and the growth stage of the plant, the plants stems can have a reduced ability to translocate nutrients to the tubers or they may be girdled and killed. Damage is greatest when the soils are cool and wet and growth and emergence of the stems is slow early in the season. Plant certified and treated seed tubers when the soil is warm and as shallow as possible to promote quick shoot emergence. Seed piece treatments containing fludioxinil or flutolanil with mancozeb are active against *Rhizoctonia* as are in-furrow applications of azoxystrobin, flutolanil, or benzovindiflupyr + azoxystrobin at planting. Product failures have been observed when periods of excessive wet and cold soil occur following planting. Since *R. solani* AG-3 is specific to potato, rotating out of potato can reduce inoculum however the sclerotia are relatively resistant to degradation so rotation out of potato of several years may be required. To reduce the development of sclerotia, harvest soon as possible after vine kill. Sclerotia tend to become larger and more numerous on the tubers as the vines senesce.

Common scab is caused by several species of *Streptomyces*, which are bacteria in the actinomycete group, a group most known for their ability to produce antibiotics. The bacteria infect the lenticels and scab forms as a wounding response to the infection. Once established in a field, common scab is difficult to manage because the pathogen can survive for years in the soil as a saprophyte in the absence of a host and its crop residue. Besides potato, other hosts of the common scab pathogen include spinach, red clover, carrot, parsnip, beet, radish, turnip, and rutabaga. Although common scab does not directly reduce potato yields, the lesions that develop on the tuber

render it unmarketable. The scab bacteria are introduced into a field through planting of infected seed, spreading of infected culls on a field or the movement of infested soil between fields on equipment. The incidence and severity of scab varies from year to year with warm, dry soils between pH 6.0 to 7.0 being most favorable for disease development especially around tuber initiation. However, additional factors such as organic matter content, bacterial species and strain, soil texture and soil moisture also influence scab development thus making consistent management both between years and across fields and farms difficult. Despite decades of research, only the use of resistant cultivars has proved to be a reliable and effective management strategy in infested soils. However, the integration of host resistance with other cultural practices that work towards creating a less favorable environment for the pathogen is also important. These include the use of long rotations of three or more years (preferable) out of any host crops including red clover along with optimizing soil moisture through irrigation management during tuber initiation, avoiding manure applications, applying gypsum rather than lime to adjust soil calcium levels and using ammonium sulfate as a nitrogen source.

Black dot caused by *Colletotricum coccodes* is primarily a root rot disease that causes early dying of plants similar to Verticillium wilt and early dying complex and therefore is not easily recognized. The pathogen has a broad host range that includes many solanaceous hosts. It is considered both soil and tuber-borne. Foliar symptoms are similar to early blight and on the tubers the symptoms are very similar, if not impossible to distinguish from silver scurf without isolating the causal pathogen. Although not a common as some other diseases, losses can be considerable because the pathogen can cause wilting of above ground portions of the plant as well as root rots below ground. Later in the season, the pathogen produces microsclerotia on the tubers, stolons, roots and stems that can survive in the soil for two to three years in the absence of a host so rotations out of solanaceous crops for three to five years are recommended. The spores produced from these fruiting bodies are considered the primary inoculum which initiates development of the disease. The pathogen is favored by warm wet weather and increased disease incidence has been associated with increased soil temperatures. Once established in the field, management focuses on reducing the amount of inoculum in the soil using practices such as removal of crop debris, volunteer and cull potatoes from the field and management of weed hosts in addition to crop rotation. Seed treatments containing azoxystrobin or fludioxinil plus mancozeb improve plant stand and crop vigor thus reducing plant stress and susceptibility to black dot. The in-furrow application of a strobilurin fungicide like azoxystrobin, have been reported to suppress stem symptoms of black dot.

Periderm disorder syndrome (formerly known as pink eye) is characterized by the progression of symptoms from ephemeral pink discoloration around the eyes to water-soaked lesions and cracked raised ‘corky’ areas around and between the eyes on the periderm surface, especially near the bud end of the tuber. The corky patches are due to the accumulation of excessive wax-like materials in the cells beneath the skin. When you cut the tuber open the tissue may have a subtle pink color and will auto-fluoresce when placed under a



UV light. This disorder leads to problems with skin removal during processing and post-harvest rots in storage, as the skin is compromised, and secondary infection can occur by soft-rotting microorganisms. This disease was once thought to be associated with a bacterial pathogen, but researchers could not reproduce the disease under controlled conditions and microscopy work has demonstrated non-pathogen associated changes in the periderm (surface of the skin) of symptomatic tubers. It has since been linked with high temperatures early in the season followed by excessive moisture. Research in Wisconsin has also linked densely compacted poorly drained soils with increased susceptibility. It has also been associated with above normal temperatures and dry conditions followed by extreme wetness that saturates the soil. Unfortunately, there are limited management options available other than making long-term improvements in overall soil health and drainage.

Designing On-Farm Potato Variety Trials for Disease & Insect Resistance

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Introduction

Potato varieties vary in their degree of resistance or tolerance to many major diseases and insect pests. Pest and disease issues of perennial concern to growers in New England include, Colorado potato beetle and early blight, both of which may impact yield through plant defoliation. However, the extent to which damage occurs is determined by an interaction of genetic traits and environmental factors. Conducting on-farm trials can provide growers with information that is specific to their unique growing conditions, which can help inform decisions around what varieties can be grown profitably at their site. The development of resistance to insecticides, especially among populations of Colorado potato beetle, provides further justification for growers to identify potato varieties that yield well in light of the pest and disease pressures endemic to their location.

Trial Design

A commonly used experimental design for agricultural field research is the randomized complete block design (RCBD). The RCBD can help account for variation in field conditions leading to greater accuracy, especially with major traits, such as yield. Accuracy is in-part accomplished through replication of experiments. Each replication is a complete block or complete set of experimental plots that are randomized. Between four and six replicates (blocks) should be used, keeping in mind that accuracy improves as the number of replicates increases. Trials should be placed on land that is most representative of the prevalent soil type and environmental conditions on the farm. Care should be taken to locate trials in areas with the least field variability. Field variability should be experienced between blocks and minimized within blocks when possible.

Variety trial designs are relatively straight forward to plan as only one treatment is being tested. Varieties of interest to the grower are selected based on existing information from published variety trials, well-documented plant and tuber traits, and yield reports. The number of varieties included per trial should be based on resource and site considerations. Plot size is also largely based on resource and site considerations with the smallest plot size consisting of six plants in a single row. With small plot sizes comes the need to collect data from every plant.
A single variety should be planted around the perimeter of the trial. This practice reduces the influence of the fields edge on the traits being evaluated. Varieties should be separated based on maturity, with early, mid, and late season varieties being grouped together in their own trials. This practice allows for mechanized harvest as well as improves efficiency in data collection.

Agronomic Factors

Plant spacings used for trials should be representative of practices used on the farm. However, wider in-row spacings of up to 18 inches prove useful when taking measurements of individual plants. This is especially true when measurements are taken late in the season when the vines of neighboring plants are sometimes interwoven. Pre-plant soil tests should be taken and any

nutrient deficiencies should be corrected either before planting or through side-dressing after plant emergence. Drip-irrigation should be used and irrigation applied based on regular readings by soil moisture probe. Potatoes are especially sensitive to inadequate soil moisture levels during tuber initiation and bulking. Water deficiency at these critical stages often results in yield reductions. Soil moisture should be carefully monitored throughout the trial to ensure that the potential of each variety is captured in the data. Preventative fungicides should be used to control foliar disease during early plant development or when environmental conditions are especially conducive to disease development. If insecticides are utilized their application should occur after insect counts or other data collection and in response to an insect count that exceeds established economic thresholds. The utmost care should be taken to ensure that insecticides and fungicides are applied evenly throughout the trial.

Evaluating Plant Defoliation and Insect Distribution

Host plant resistance (HPR) to Colorado potato beetle (CPB) in potato functions through either antixenosis or antibiosis. Antixenosis resistance is a plant-borne deterrence mechanism that prevents colonization of insect pests. Antibiosis is a mechanism that operates after colonization and affects the insect's growth and development, leading to reduced survival and reproduction. Each of these resistance factors can be evaluated independently.

Antixenosis is evaluated through what is known as a field choice test where insects are free to choose their host in the open environment. Varieties are evaluated for potential antixenotic HPR to CPB by counting the number of nymphs and adult found on each plant. Varieties are evaluated for potential antibiotic HPR to CPB by measuring the incidence of leaf predation.
In foliar diseases, such as early blight, HPR can be evaluated by measuring the incidence of leaves showing symptoms. In the case of leaf predation and symptomatic leaves measurements are taken as a percentage of total foliage.

Evaluating Yield & Tuber Qualities

Tubers are often harvested in bulk from each plot, counted, and weighed in pounds per plot. Tubers are then sorted by size and marketability. Other important measurements that can be taken include incidence of wireworm damage and tuber deformities. In all cases data is taken as weights, usually in pounds.

Improving High Tunnel Tomato Fertility

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Background: High tunnels create a growing environment distinct from the field, with no rain and warmer conditions. As a result, after a few years in production, tunnel soils develop altered characteristics, which in turn affect nutrient mineralization rates, soil moisture, leaching, pH, and soil biology (Hoskins, 2010). The lack of rainfall and predominant use of drip irrigation over multiple years have led tunnel soils to be characterized as "irrigated deserts" with high salt levels in the top 1-2 inches of the soil (Thongsin, 2011). Because high tunnels are such a valuable growing space, many farmers heavily fertilize tunnel soils to feed the densely planted and highly productive space. Unlike hydroponic (soilless) vegetable production in greenhouses, nutrient management is not well defined for in-ground growing in high tunnels, and little guidance as to fertilizer application has historically been available.

In the Northeast, tomatoes are the most widely grown high tunnel crop because they utilize vertical space well, have strong market demand, and tunnel production significantly improves their yield and quality. Previously, fertilizer recommendations for high tunnel vegetables were loosely based on field crop recommendations, without specific consideration for the growing and soil conditions in a tunnel. Recommendations based on field soil tests are calibrated for yield goals in outdoor production, so when applied to a tunnel, field soil tests typically generate nutrient recommendations that are too low for tunnel crop needs. In 2011, the University of Maine Soil Testing Service began to offer a high tunnel soil testing package that included saturated media extract (SME) in conjunction with field soil tests. The SME measures "nutrient intensity", or the pool of water-soluble nutrients immediately available for plant uptake. Taken together, the two test results more accurately predict nutrient availability in a tunnel scenario, but specific crop nutrient demands in tunnels, especially tomatoes, was still not well understood.

In 2018, a collaborative effort among soil labs and extension specialists from Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont set out to conduct a broad analysis of growing practices by collecting data from 20 high tunnels. This work resulted the New England High Tunnel Survey (Campbell-Nelson et al., 2018), with revised nutrient recommendations that are now utilized by the University of Maine Soil Lab and Extension professionals around New England.

Research: This project sought to build on the 2018 high tunnel survey by motivating more farmers to use the UMaine High Tunnel Soil test and implement the new nutrient recommendations. This project also tested the effectiveness of the recommendations by using a participatory approach that combined the use of soil test data with farm specific information. A soil testing "intake form" was developed for growers to complete that documents their management practices and yield goals. This information was used to develop individualized soil health recommendations in conjunction with the UMaine high tunnel soil test results. In 2020, 69 farms participated in the project and used the revised testing protocol, with 51 farms participating in 2021 (138 and 104 tunnels, respectively). We also visited five partner farms monthly to take soil and tissue tests and to better understand how the revised nutrient recommendations played out on a month by month basis.

Results: Nutrients. Although all the farms in the study amended their tunnels according to recommendations, levels of early season nitrate and potassium levels varied widely and were linked to marketable yield. In the five case study tunnels, when N and/or K were below a target level (~150 ppm NO^3 and ~1500 ppm K_20) at one month after transplant, marketable yields were 40-60% less (however, since this was not a controlled study, there were many other variables impacting the yield numbers).

Tissue samples. This project highlighted the utility of tissue sampling one month after transplanting; in particular, fertigating in response to moderate to low tissue test levels resulted in a rapid plant response. The tissue tests also affirmed previous research about the importance of insuring plants have access to the high levels of potassium necessary for the duration of the growing season.

Other practices that impact yield. Although nutrients are foundational to tunnel tomato production, other practices may have as significant or a greater impact. When measuring marketable tunnel yields in pounds per square foot, planting density was the biggest single predictor of yield. Farms with tight plant spacing of 2-2.5 ft^2 per leader had the highest yields per square foot (5-7 lb per ft^2). Tunnels with generous spacing for tomatoes to 3-4 ft^2 per stem had lower yields of 2 lb/ ft^2. High density planting requires good airflow, intensive horticultural management, and low disease pressure. On the other hand, spacious plantings allow for more worker comfort and can reduce disease pressure.

Overall project impacts. Growers reported that using the revised recommendations led to an average of a 30% increase in marketable tomatoes during both project years (2020 and 2021). The average yield from tunnels in the project across both years was 3.3 lb/ft^2, which is equivalent to 71 tons per acre. In comparison, the field average for tomato harvests in Vermont is only about 5 tons/acre (NASS, 2017)—indicating that high tunnels can produce up to fourteen times more marketable fruit than in the field. Furthermore, growers who participated in both years of the project reported a yield improvement of 30% between 2020 and 2021 (2.7 lb/ ft^2 and 4.3 lb/ ft^2, respectively), which reflects the positive outcomes from multiple years of building soil health and following these nutrient recommendations in a tunnel.

Conclusions: This project reveals how widely farms vary in practices, tunnel shapes, sizes, and soils. Furthermore, there is no one size fits all approach for high tunnel production—every farm has different markets, goals, and circumstances. Refining an intake process and allowing farmers to articulate their desired outcomes is an important part of building these recommendations. Finally, improving soil fertility is just one small part of optimizing high tunnel production, and this project is a step towards more comprehensive high tunnel guidance.

Below are summary recommendations based on this project and the 2018 high tunnel survey**:**

1. Set yield goal. Reasonable goals = 3-5 lbs/ft^2.
2. Soil test for available AND reserve soil nutrients.
3. Fertilizer application should be based on soil test results and yield goal, otherwise you are guessing!
4. Keep an eye on pH and salts with annual soil tests. Both creep up quickly!
5. Phosphorus: don't over-apply, crops do not remove a lot, tunnel soils are warm.
6. Potassium: is removed in large quantities by tomatoes. Make sure adequate K is available, especially as fruits form.

7. Nitrogen: is also removed in large quantities, provide sufficient available N for biomass production through the entire growing season. Front-load slow-release amendments and/or apply soluble fertilizer during the season.
8. Take tissue samples one month after transplanting; be prepared to fertigate N and K. Recommended rate is 0.25 lb of N and K_20 per week.
9. Have at least 2 drip lines per plant row; sandier soils 4 lines. Irrigate regularly (use an automatic timer).
10. Transplant at higher density 3-5ft^2 per leader.
11. Graft plants for stronger roots, especially if soil conditions are not optimal.
12. Track performance: measure harvests, even if simply counting boxes.
    (Campbell-Nelson et al., 2018)

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Thank you to the farms that participated in this project!

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Heat Stress and other Abiotic Disorders of Tomato

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All of the fruit disorders that will be discussed here are abiotic, i.e., they are not caused by living pathogens or other pests, but by environmental factors. In many cases, the key to avoiding these disorders is proper fertility, a good irrigation program and smart cultivar selection.

Blossom end rot starts with a light tan, water-soaked lesion, on the blossom end of a fruit. This spot then enlarges and turns black and leathery. Secondary organisms frequently invade this lesion and cause complete rot of the fruit. The cause is a localized calcium deficiency in the blossom end of the fruit because calcium is not highly mobile within the plant. Calcium is taken up mostly through the water-conducting tissues of the plant, so if the plant isn't taking up water even for a short period of time calcium deficiencies can develop. It often occurs in rapidly developing fruit during periods of hot, dry weather and tends to have the greatest impact on the earliest maturing fruit. Other conditions that reduce calcium uptake by the plant, such as high salts, the use of ammonium nitrogen, and high relative humidity can exacerbate the problem. Blossom-end rot can be managed by proper water management, fertility and planting cultivars tolerant to blossom-end rot.

Leaf roll is usually a reaction by the plant to conserve water by reducing the surface area of the leaf. This disorder is often seen just after plants are heavily pruned under dry soil conditions, but also has been found to be caused by excess soil moisture coupled with extended high temperatures. When foliar growth is more vigorous than root growth and the plant is exposed to hot, dry conditions the foliage may transpire water faster than the root system can absorb it and the plant rolls it's leaves up to reduce transpiration. This disorder mainly affects lower leaves. Cultivars that are high yielding or early ripening tend to be more susceptible, while indeterminate cultivars are more sensitive than determinate. Although it can look bad leaf roll rarely effects plant growth, fruit yield, or fruit quality. You can reduce symptoms by maintaining consistent, adequate soil moisture, which also will reduce blossom end rot. You also should not prune heavily during hot, dry conditions or over-fertilize with nitrogen.

Catface in tomatoes causes misshapen fruit, with enlarged scars and holes in the blossom end of the fruit and is more common in heirloom cultivars. This disorder is still not fully understood. Cold temperatures during flowering have been shown to increase incidence of catface, as has extreme fluctuations in night versus day temperatures. Chilly weather (~50°F or lower) at the time of blossom set distorts and kills particular cells that should have developed into fruit, resulting in the deformities. The disorder is most often observed in first-formed fruit. There is research that shows catface also can be caused by thrips damaging the side of the pistil of tomato flowers as well as exposure to growth regulating herbicides such as 2,4-D. Growers should avoid excessive pruning and nitrogen fertilization and use cultivars that are less prone to catface.

Stitching or zippering is seen when a thin, brown, necrotic scar extends from the stem to the blossom end of the fruit. The longitudinal scar has small transverse scars along it, making it resemble a zipper. Fruit can have one or several scars. This disorder is purely cosmetic, but may render fruit unmarketable. Zippering is thought to be caused by the anthers (the pollen-producing flower part) fusing to the ovary wall of newly forming fruit. This disorder occurs more frequently in cool weather.

Fruit cracking consists of three types; concentric cracking is the splitting of the epidermis in circular patterns around the stem scar, while the 2nd type is radial cracking which is the splitting of fruit that radiates toward the blossom end from the stem scar, the third type is rain check, which occurs when very small cracks form around the shoulders of fruit. These cracks are caused by rapid water uptake by the plant during fruit development, when interior tissues expand faster than the inelastic skin. Rain check also often occurs when developing fruit is subjected to over exposure to the environment, i.e., sun and rain. All of these cracks usually occur on tomatoes as they near maturity. Some cultivars do not crack until the breaker stage, while more tolerant cultivars do not crack until they are red and resistant cultivars rarely crack at all. Cracking is associated with rapid fruit development and wide fluctuations in water availability in the plant. Fruit that has reached the ripening stage during dry weather may show considerable cracking if the dry period is followed by heavy rains and high temperatures. Growth cracking can be reduced by proper water management, practicing a good nutritional program to prevent overly succulent plants, planting cultivars tolerant to cracking and preventing defoliation due to foliar diseases to limit fruit exposure.

Yellow shoulder, blotchy ripening and internal whitening are three fruit ripening disorders not completely understood, but I lump them together here because they have some common causalities. Yellow shoulders affects the shoulders of tomato fruit. Chlorophyll in the shoulder area is slow to break down as ripening occurs, which results in an area that does not ripen properly. Blotchy ripening is characterized by yellow or orange discolored areas on tomato fruit surfaces. Tomatoes with internal whitening have outer and inner fruit walls that become white and corky. These ripening disorders are often seen when potassium (K) levels drop below 2.7% in leaf tissue analysis during fruiting. K levels can drop quickly during fruit production in tomatoes and plants have a difficult time supplying the fruit with enough K. These ripening disorders are also more prevalent when air temperatures during mid-late stages of fruit ripening are $\geq$90°F day or $\geq$70°F night or are highly variable and when humidity levels are very high. Growers need good irrigation and nutrient management to reduce the risk of these disorders. Feeding K through the drip lines during the fruiting period and using shade cloth or white plastic mulch (see heat stress section) will help reduce the severity of these disorders.

Sunscald occurs on green tomato fruit exposed to the sun. The initial symptom is a whitish, shiny area that appears blistered. The killed, bleached tissues gradually collapse, forming a slightly sunken area that may become pale yellowish and wrinkled as the fruit ripens. The killed tissue can be invaded by secondary organisms. Sunscald is more of an issue with fruit that has been exposed suddenly to the sun because of loss of foliage from foliar diseases (most commonly), pruning, or less commonly from spreading of the plant foliage because of a heavy fruit load. Sunscald can be managed by good foliar disease control, careful pruning and

harvesting, using cultivars with good foliage cover and using a 30% shade cloth over the top half of the tomato plant (see below for more information).

Heat Stress occurs in tomatoes when daytime highs are $\geq 90^{o}$F and nighttime lows only getting down to 68-70°F. These temperatures may result in blossom drop, fruit abortion and fruit ripening problems in tomatoes. At these temperatures the pollen can become sticky and nonviable, preventing pollination from occurring and causing the blossom to drop.

There are some possible remedies to these high temperatures that could increase pollination and fruit set. One of the things is using shade cloth that is draped over the tomato stakes when plants begin to set fruit. After many years of trials, my research has shown that a 30% shade cloth can increase marketable yields by 20-50%, and increase quality and size of tomatoes significantly. A 4 ft-wide shade cloth covering the top 1/4 or 1/3 of the crop canopy is enough to increase yield, and the shades can be used for many years. Another tactic is to use white plastic mulch instead of black plastic mulch for mid-summer ripening tomato fruit. The white plastic mulch reduces soil temperatures so that tomato roots can more readily take up potassium. While white plastic mulch helps reduce fruit ripening problems, it is not as effective as using shade cloth. I do not think a grower should go out and cover all of their tomato fields with shade cloth, but it could be used for tomato varieties that you grow because your customers really like them, but they just do not produce well in the summer heat. Using a 30% shade cloth to cover high tunnels in mid-summer is also a good idea as this will reduce daytime and more importantly from a quality of fruit standpoint night time temperatures in the high tunnel. Night-time temperatures of 70°F or above really increase fruit ripening problems

Edema (or sometimes spelled oedema) is becoming a greater problem in high tunnels that start very early in the season and appears as blister- or callus-like growths usually along veins that first appear on the underside of older leaves. Leaves also show unusual curling and other odd distortions on the top side of the leaf as well as yellow spots on the upper surface of the leaf. Leaves with a great deal of this blistering will become brittle with the leaf often cracking with any type of handling. Edema is caused by the buildup of excess water in the root and conditions unfavorable for transpiration, usually caused by high humidity, low light and little air movement. When the tomato plant cells get too much water the cells will expand faster than they can get rid of the water leading to split and cracked tissue. Extensive edema can severely decrease the leaf's photosynthetic capability and lead to senescence. Basically overwatering, high humidity and low or poor light are the major causes for the development of edema in plants. Therefore, avoid overwatering plants in the high tunnel or greenhouse especially during cool temperatures or overcast conditions when they should be kept slightly on the dry side. Keep humidity levels below 70% by enhancing airflow around the plants and by spacing the plants farther apart. And finally, if possible though more complicated, research has shown that increasing light quality in greenhouses by providing a more "full-spectrum" of light output, with significantly more short wavelength energy (i.e., UV light), will also decrease the occurrence of edema.

Growing Tomatoes Outdoors for Processing

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12/15/22

Intro

Growing tomatoes is the easy part. Selling them when they come in is a complicated and challenging business. When tomatoes are in the peak harvest season, demand seems to vanish. Farmers, stuck with huge amounts of top-quality stuff, suddenly are dumping them in the pig pen. Buyers in this market can't really adapt to the seasonal nature of the harvest. They want their menus and SKUs to change as little as possible. A summer menu, for example, might run from June through August. Buyers need tomatoes consistently for that period even though on our farm, (outdoor) tomato season is August 1 to mid September. 6 lousy weeks, when everyone else is on vacation.

At KGF, we figured that by preserving our tomatoes and offering them as value-added products (salsa, passata, whole peeled), buyers could keep our in-season tomatoes in stores year round. We grow them outside, when it's relatively cheap and easy, without trying to chase that out-of-season tomato.

Overview

Here at Kitchen Garden Farm we are currently growing about 40 acres of vegetable crops a year for wholesale and our own value-added products. Acreage devoted to crops for processing makes up 25% of our land but sales of products make up about 55% of our revenue. We have been producing our flagship sriracha sauce since 2013. For 5 years we worked out of a shared facility in Greenfield, MA (the Western Mass Food Processing Center). In 2019 we built our own 2800-square-foot facility where we make all of our products. The product line has grown to include two types of salsa, passata, whole peeled tomatoes, giardiniera (mixed vegetable pickles), dried chilies (both whole and powdered), and herbs. We sell over $1 million worth of these products per year from around 10 acres of our own vegetable crops.

Passata

The largest share of our tomato crop goes into making passata. Passata is a concentrated tomato puree typical of southern Italy. In 2022 we processed 28,000 lbs of tomatoes into passata. We try to make this product as close to what you would get from a small artisanal processor in Italy. We source the seed for our tomatoes from Italy as well as the traditional glass jar. The tomatoes are picked ripe on the vine and processed immediately. The tomatoes are washed, roughly chopped, and heated up to release their water. The solids are strained out and the water discarded. The resulting pulp is then run through a passata machine (also from Italy) to eliminate seeds and skins. We add salt and lemon juice to the resulting puree and hot-fill into glass at 195 degrees to ensure pasteurization. In 2022 we made about 650 cases of passata. A case of 12 24-ounce jars is sold wholesale for $72. The passata retails for around $8.99-$9.99.

The challenge we faced when developing this product was to make sure it was profitable enough to justify making. Each jar of passata requires 3 lbs. of tomatoes to make. If you value the tomatoes that go into it at farmers' market prices, you'd clearly be losing money. We had no intention of making a "value-subtracted product." We determined that the efficiencies gained by growing a lot of tomatoes and harvesting them based solely on ripeness and not salability, we were able to lower the cost of production to $0.37 per pound (see attached sheet).

Salsa

The other primary use for our tomato crop is for preserving it as the primary ingredient in our roasted chili salsa. Preserving tomatoes for salsa is more economical than making passata because the tomatoes are simply blanched and pureed whole. The resulting slurry containing all the water, seeds, and skins from the tomatoes is packed into 5-gallon buckets and frozen until needed for bottling salsa. We are able to work with a lower-quality tomato puree for the salsa because the other ingredients (roasted onions, garlic, and chilies) thicken the salsa, and a chunky texture is desirable. In 2021 we built a freezer warehouse on the farm to store the frozen salsa ingredients. The salsa is bottled primarily in the off-season (November to May) to save labor for in-season processing. We will turn 20,000 lbs. of frozen tomato puree into 3,045 cases of salsa this year. A case of 12 sells for $66.

Climate Considerations

Farmers are on the front lines of climate change, impacted physically, mentally, and financially by the intensifying swings between drought and deluge. While no one can predict the weather day to day or month to month, the one thing that is certain is that the summers are getting hotter. In my region, August 2022 was the hottest ever, with an average temperature of 73 degrees, which was 6.5 degrees higher than the baseline. In response, our farm has moved toward a greater emphasis on heat-loving crops like peppers and tomatoes, as extreme high temperatures take an ever-increasing bite out of our fairly short, temperate growing season. This change has narrowed the planting and harvest window for leafy crops such as lettuce and broccoli. Even in wet years such as 2021 with record-setting rainfall totals during our harvest season, our farm was still able to harvest large amounts of these crops for processing, proving the resilience of our on-farm processing model.

Seed to planting	amount	unit	cost per unit	total
Seed cost	8	M	55	$440.00
Potting soil, VC	0.5	sling	800	$400.00
Trays (multi use)	160	50 cell	0.375	$60.00
Seedling labor	30	hours	18	$540.00
Tractor expense	12	hours	50	$600.00
Operator labor	12	hours	18	$216.00
Fertilizer	50	bags	28	$1,400.00
Plastic Mulch	4	rolls	120	$480.00
Drip Tape	3	rolls	160	$480.00
Planting Labor	36	hours	18	$648.00
Total Planting Cost				**$5,264.00**

Maintenance				
Stakes (multi-use)	4000	stakes	0.75	$3,000.00
twine	16	box	8	$128.00
Staking, 1st pass	160	hours	18	$2,880.00
Staking, subsequnt	50	hours	18	$900.00
Cultivation/Mowing	12	hours	18	$216.00
Grass seed	1	Bag	50	$50.00
Mower & Fuel	1		100	$100.00
Spraying, Chemicals	3	times	50	$150.00
Spraying labor	6	hours	22	$132.00
Cleanup Labor	80	hours	18	$1,440.00
Disposal	1	Estimate	200	$200.00
Total Maintenance				**$7,556.00**

Harvest	(1 person+ 8 hours=1000 lb)			
Harvest labor	480	hours	18	$8,640.00
Truck & Fuel	$25	per day	24	$600.00
Crates (multi-use)	250	crates	$0.50	$125.00
Total Harvest				**$9,365.00**
Total Production Cost				**$22,185.00**
Total Yield (lb)				**60000**
Cost per pound				**$0.37**

Soil steaming in high tunnels: Impacts on soil biology and lessons learned

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Background: In recent years, common chickweed (*Stellaria media***)** has become a widespread problem in high tunnel winter greens production in the Northeast. Chickweed is especially well adapted to growing in high tunnels; it emerges primarily in the fall, with optimal germination temperatures of 53°F to 68°F. It can flower within a month and set seed in 2 to 3 months, producing an average of 25,000 seeds per plant (Michigan State University). Chickweed is very hard to control manually, with a fibrous root system that is difficult to hoe or hand pull. Severe chickweed infestations can lead to significant or total economic losses in tunnels.

An emerging technology used by growers in the Northeast to manage weeds and pathogens is soil steaming, which has long been used in floriculture greenhouses, tobacco fields and other commodities. The current method used by most high tunnel growers is called "sheet steaming", which deploys a portable boiler to generate steam that is applied through a "sock" placed under a heavy tarp covering the soil surface, raising the temperature in the top few inches of soil as high as 83°C (180°F).

Though soil steaming is used worldwide, in part as an alternative to fumigating with materials such as methyl bromide, little is known about its effect on soil biology. Previous research has indicated that favorable soil biology is sensitive to "over treatment" from soil steaming (Fennimore et al., 2014), but may "recolonize" quickly after treatment (Fenoglio et al., 2006). The lethal temperature for different soil organisms has been well documented, and it is known that most weeds are killed at lower temperatures than soil microorganisms (Baker & Chandler, 1957). Previous research has also indicated that nutrient imbalances can occur after steaming (Fennimore et al., 2014), which can impact subsequent cash crop growth.

Moist soil, 30 minutes at	Organisms killed
115°F	watermolds (oomycetes)
120°F	nematodes
140-160°F	soil insects
140°F	most plant pathogenic bacteria and fungi
160°F	all plant pathogenic bacteria; most plant viruses
160-175°F	most weed seeds
200-212°F	heat resistant plant viruses and weed seeds

Source: Baker, K.F., 1957.

Research: This project examined the effectiveness of different steam temperatures on chickweed infestations and spinach yields. We also assessed the impact on microbial populations by collecting soil samples throughout the season and analyzing them for biological activity.

Beginning in October of 2020, we soil steamed two tunnels on the same farm, one with "moderate" and one with "high" chickweed infestations, for three consecutive autumns. The goal was to trial three soil temperatures, 140° F, 160° F, and 180° F in each tunnel and compare them with an unsteamed control. We collected soil samples prior to steaming, one week after steaming, one month after steaming, six months and one year after. The samples were analyzed for soil nitrate (UVM soil lab) and for microbial activity using the Biolog Ecolog plate, which is a technique that characterizes carbon and nitrogen substrate utilization as in indicator of microbial populations.

Results:

Chickweed. A steam temperature of 160°F (2 inches deep, 30 minutes) achieved excellent chickweed control, with no emergence in these plots. Plots steamed at 140°F (2 inches deep, 30 minutes) also demonstrated good chickweed control, with little to no emergence. Steam temperatures of 120-140°F provided limited control, with an estimated 40% chickweed mortality. Damping off was reduced in all plots steamed above 140°F, leading to improved stands of direct seeded spinach.

Microbes. The Biolog Ecoplates used to evaluate the impact of steaming on soil microbes reflect two things: 1) Average Metabolic Response (AMR), which measures how quickly microbes are consuming substances in the soil (e.g., microbe activity) and 2) Community Metabolic Diversity (CMD), which is a measure of the variety of substances consumed (e.g., diversity of active microbes). Data from 2020 and 2021 show that there was an initial decline in AMR (rate of microbe activity) immediately after steaming, but rebounded within a year of steaming. CMD showed no impact, indicating that the diversity of microbes was not impaired by steaming.

Nitrate. Soil nitrate results showed a drop in nitrate at the higher steam temperatures of 160°F and 180°F, but an increase at 120°F in the immediate weeks after steaming. The samples taken at 6 months and 1 year show no long term impact on soil nitrate availability related to steaming.

Costs & yield. We compared the costs of hand weeding chickweed versus soil steaming and yields in unsteamed versus steamed plots. Unsteamed areas yielded an income of $3.15 per square foot after deducting the costs associated with handweeding. In comparison, the steamed areas had an average income of $8.74 per square foot after subtracting the expense of steaming.

Steamer purchase, accessories, & delivery	$6,500
Annual cost per tunnel if used for 10 years, 3 tunnels/ year	**$217**
Fuel (diesel or kerosene) per 30x96 ft tunnel	
55 gallons @$5/ gallon	**$ 275**
Person time	
(8 hours per tunnel @ $18/ person hr)	**$ 144**
total cost per 30x96 sq foot tunnel	**$ 636**
cost per square ft	**$ 0.22**

Conclusions:

This research indicates that soil steaming to temperatures between 140 and 160°F (2 inches deep, 30 minutes), is a very effective and economical way to control chickweed and damping off with minimal long term impacts to soil health. However, because these data reflect a drop in microbe activity immediately after steaming, we recommend that growers proactively employ practices to boost their soil biology through the use of compost and other "living" soil amendments. It is important to note that this research was limited to studying effectiveness of steaming for chickweed control in winter greens production, and did not examine other applications where a higher steam temperature may be necessary, such as for crops with deeper planting depths and different pathogens (e.g., flowers or tomatoes).

This research also revealed some basic trends in high tunnel soil biology. In 2021, one round of sampling was taken before steaming, when the soil was very dry and had been empty of plants for a week. Both AMR and CMD results from Ecoplates showed practically no microbe activity or presence. It was striking that the negative impact on microbial communities from leaving soil dry and bare was more severe than it was from steaming.

We used two types of steamers for this research: a 1950's low pressure tobacco steamer (purchased, used but retubed) and a 2021 Sioux Model SF-20 steamer (rented from the Cheshire County Conservation District in New Hampshire). With both steamers, it was challenging to achieve the steam temperatures to 180°F, which we had hoped to in order to understand the impact of the higher temperature on soil microbes. We were also surprised by how unevenly distributed temperatures were within plots. A more accurate system would improve outcomes, especially with the awareness that there is a temperature range that kills chickweed but does not destroy the soil ecology.

Overall, this work demonstrates that steaming can play a key role to manage chickweed and soil borne pathogens. However, we also conclude that sheet steaming is fuel and labor intensive and somewhat inaccurate. It's exciting to recognize that there are modifications possible to this system, as well as more advanced steaming techniques used in larger farming systems. For example, other parts of the world utilize soil mixing and steam injection for efficient application of steam (Fennimore et al., 2014; Fennimore & Goodhue, 2016). A challenge for growers in the Northeast is to adapt this technology to an appropriate and affordable scale. In the short term, we anticipate increased adoption of sheet steaming by farmers in the Northeast, and believe that a shared use arrangements for soil steamers, such as in Maine and New Hampshire, will allows more growers to access this effective technology.

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Disease Updates in Winter Greens

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There are several disease issues that can cause problems in winter greens. **Damping off,** a common soilborne disease, is likely the first problem encountered. This disease is caused by several different soilborne fungi that live in all soils. The fungi prefer cool wet conditions and can cause a rot of young seedlings before or after they emerge. Anything you can do to favor rapid germination of your greens will help avoid the destructive disease. Use of heat mats, sanitized/clean flats, good plant spacing and avoiding overwatering especially when cloudy or cool will all help insure healthy seedlings. Soil amendments can also help minimize losses. Tunnel soils high in organic matter have high water-holding capacity and under cool conditions may stay wet for longer periods of time. Use of Trichoderma amendments such as Rootshield may also add some protection from the damping off fungi but should only be used along with good growing practices. Be aware, formulations of Rootshield only become active when soils are over 50 F.

Lots of crops get downy mildew but each downy mildew pathogen has a very narrow host range specific to each crop with no transfer between crops. All downy mildews need a living host to survive. **Spinach downy mildew** (DM) is the most important spinach disease and is favored by cool, moist conditions. The disease is easy to diagnose-the upper surface of the leaf shows yellow discoloration that looks like a nutritional issue with the undersides showing purplish-brown spores. There is a possibility the pathogen can produce a long-term overwintering spore, but there is currently no evidence of this occurring in New England. Incidence of the disease is on the rise most likely a result of the increased use of high tunnels for winter spinach production. Any overlap of field spinach and high tunnel spinach can create a "green bridge" for the disease, allowing the pathogen to move between fields and high tunnels. As of 2021, there are 19 numbered races of spinach downy mildew, along with numerous "novel" races. Spinach DM management relies on the use of resistant cultivars, as well as managing relative humidity and leaf wetness. Select cultivars with resistance to races 1-19, if possible, and grow multiple cultivars with different race-resistance. Once infected, there is little that can be done to manage spinach downy mildew. Rotate out of spinach for at least two years.

Lettuce, kale and other brassicas are all susceptible to downy mildew, but each downy mildew pathogen has a very narrow host range specific to each crop with no transfer between crops. Initial symptoms of **lettuce downy mildew appear** on upper leaf surface as light green to yellow angular areas bounded by major veins. Diagnostic white fluffy growth of the pathogen develops usually on the lower leaf surface associated with the lesions. Affected tissue eventually turns brown. Older leaves often are affected first. Potential initial sources of the pathogen include spores dispersed by wind from other lettuce plantings, plant debris from a previous infected lettuce crop, and contaminated seed. Manage by selecting resistant varieties and use of conventional and organic fungicides**.** Fungicides can be found in the NE Vegetable Management Guide **https://nevegetable.org**. **Downy mildew of kale and other brassicas** develops when

temperatures are 46-61F at night and below 75 during day. Leaf spots can develop that are similar to those in lettuce being yellow and bordered by large veins with white downy pathogen growth on the leaf underside. Symptoms vary among brassica crop types and some brassicas on the farm may not be infected where others are infected on the same farm due to pathogen specificity. Sources of the pathogen include contaminated seed, plants surviving over winter, sexual spores (oospores) in debris, and wind-blown asexual spores. Other hosts, in particular cruciferous weeds, can play an important role in the disease cycle. Select pathogen free seed, inspect plants routinely for symptoms, minimize leaf wetness and high humidity, remove affected crop debris after an outbreak when feasible or destroy it. Fungicides may help with control.

Spinach leafspot diseases can be a limiting factor in spinach production with the main two being **Cladosporium leaf spot** and **Stemphylium leaf spot**. Both fungal pathogens are seedborne and thrive in cool, moist conditions between 59° - 68°F and RH> 80% but can tolerate temps as low as 41F and high as 86F. Cladosporium leaf spots are tan and can expand to 1-3mm in diameter. Spots may coalesce to form irregular lesions and velvety dark green-brown sporulation develops within the lesions. In severe cases, older infected leaves may be killed. Stemphylium leafspots are light gray to tan up to about 1/2 inch with larger spots being irregular in shape. Initially spots can be grayish green but eventually dry up and become papery. Use of hot water seed treatment or chlorine seed treatment can reduce the chance of seed borne transmission. Use drip irrigation or overhead irrigate early in the day on sunny days, when possible, so that crop foliage will dry quickly. Heating and venting may be necessary to reduce relative humidity. Control weeds within your crop and at the outside edge of high tunnels, to increase air flow and eliminate possible weed hosts. The pathogens may overwinter on infected tissue, clean up debris at the end of the season. No spinach cultivar is completely resistant (immune) to the diseases. However, research has indicated that significant differences in both incidence and severity of the disease exist among different cultivars. For Cladosporium, Winter Bloomsdale is more resistant than Ozark or Fall Green.

Three **physiological disorders** can occur on winter high tunnel spinach. Although spinach can withstand frost well, **freezing damage** can kill and brown leaf tissue. Minimize by using extra row covers or low tunnels inside high tunnels. **Oedema** results when water pressure causes cells to burst, resulting in scab-like calluses on the leaves. Minimize by limiting irrigation and maintaining low relative humidity as temperatures drop and growth slows. Under winter and spring conditions, spinach often forms natural leaf structures called **glandular trichomes** on upper and lower leaf surfaces that resemble tiny water droplets or insect eggs growing from the leaf surface on tiny stalks. These trichomes are harmless and part of the plant.

Symptoms of **powdery mildews of kale, other brassicas, and lettuce** include characteristic superficial white fungal growth (powdery appearance) of the pathogen on both leaf surfaces. Leaves can quickly become covered. Powdery mildew pathogens have narrow host ranges, thus different pathogens cause powdery mildew in kale and lettuce. Similar to the downy mildew pathogens, they only develop on living hosts. Unlike downy mildews, powdery mildews do not need long periods of leaf wetness or high humidity to develop and develop best under dry conditions. Kale is more commonly affected than other brassica crops as a result of variation in

susceptibility and/or physiological specialization in the pathogen. There are several organic fungicides that can control powdery mildew.

Natural Wine Experience and Understanding Amongst New England Producers

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Natural wine is a concept borne out of a desire for simplicity. However, defining and implementing its practices may not be so simple. This concept of a "natural wine" has garnered a lot of attention recently as the interest moves from its origins in Europe to other countries such as Brazil and the United States. As natural wine continues to be a topic of conversation in popular wine magazines and organic wine circles, the vague nature of its practices is a common talking point. Most articles, both in the media and academia, caution that natural wine currently lacks a concrete definition amongst growers and most governments. The most tangible regulations surrounding natural wine are seen in France, where natural wine is now legally referred to as vin methode nature (González, Dans et al. 2022). This new legislation requires that all grapes going into the wine must be certified Organic and hand harvested (SDVN, 2022). This management strategy in the vineyard is matched with a restriction on the use of any wine additives like sulfites, non-native yeasts, or stabilizers. The wine must also be spontaneously fermented. The general theme of natural wine is fairly similar across the world to this definition, however the details of how this is done varies across the world. In fact, many proponents of natural wine fiercely refute this certification, as it does not sufficiently uphold the sentiment of the practice of natural viticulture and winemaking (González, Dans et al. 2022). There is a general confusion about the practices involved in the creation of natural wine, particularly in countries that do not regulate the industry. This lack of clarity may create a large barrier to entering the natural wine market.

In recent years, New England has garnered growing attention from the wine industry. Growth in the industry can be attributed to the addition of high quality and cold hardy varieties (Bradshaw, Berkett et al. 2018), climate change concerns (Hannah, Roehrdanz et al. 2013), and a growing interest in local products (Jacobsen R., 2019). As of 2021, UMass reported 120 operational New England vineyards, with more expected in the coming years (UMass, 2022). As the wine industry of New England currently stands, most wine produced is sold directly from the winery (Bradshaw, 2022). New England is known for its value-added products based on locality and consumers' growing interest in supporting local farms (Berlin, Lockeretz et al. 2009). These wineries are supported not only by locals, but also tourists following "New England wine trails" and vineyard tours. This indicates the importance of vineyard-based tourism within the industry. Interest in local agriculture, paired with the worldwide growing interest in Organic and sustainable agriculture (Gallenti, Troiano et al. 2019), may create the perfect niche for natural wine production in New England. An opportunity for this business strategy would allow New England winemakers to fetch significantly higher prices, as most natural wine currently sells for at least $20 a bottle, and often over three times that amount (T. Bradshaw, personal communication, October 24, 2022).

To better foster the growing industry in New England, it is important that researchers understand where grape growers and winemakers stand on the subject of natural winemaking. To

do this, a group of researchers at the University of Vermont constructed an online survey seeking to answer three main questions: How do New England growers define this concept of natural wine? What experience do growers have with practices common in the natural wine industry? And lastly, have they personally tried any of these practices with the intention of growing/ producing a more "natural" product? The survey was conducted for one month and has a total of 12 complete responses. While this sample size is small, it is important to note that 10 of the 13 responses were growers from VT. These Vermont respondents reported having a total of 81.3 acres either leased or owned for grape production. This is 42.3% of the states reported grape bearing acreage. This significant proportion of the total grape acreage allows us to use this survey as a representative sample of Vermont wine grape growers.

Survey results show that most have heard of natural wine through one route or another and can provide some personal definition of natural wine and natural viticulture. Most of the natural viticulture definitions (53%) focused on a restriction on pesticide use, largely associated with restrictions in allowable materials in organic or biodynamic spray programs. Three of the thirteen responses mentioned an increase in biodiversity either in specific or general terms. Similarly, natural wine definitions focused on a restriction on wine additives (61.5%) and/or the use of wild yeasts. A notable portion of respondents also expressed uncertainty about the term 'natural' within their written responses. These definitions may reflect not only uncertainty about the terms natural wine and natural viticulture, but also a focus on the restrictions on management tactics as opposed to common management strategies. This lack of known natural management tools is further supported by responses concerning EPA registered biopesticides. These pesticides are often used in the natural wine community as they fall within organic certification requirements and are generally seen as having low environmental or health impact. Survey respondents who have used these products reportedly found their effect satisfactory or better. However, of this same group, only half used the product with the intention of practicing natural viticulture. If growers felt more secure in their disease management options within the natural wine market, they may feel more confident entering such a market.

Grower interest in natural production methods was evident throughout the survey. 10 of the 12 responses to questions about natural wine understanding answered that they had either researched natural wine (3 respondents) or believed they have grown under natural management conditions (7 respondents). The majority of respondent growers say they have not used synthetic pesticides such as Mancozeb and Rally in their vineyards. In comparison, over half of respondents have used several of the listed alternative pesticides such as Copper, Sulfur and Biodynamic preparations. This demonstrates that respondent growers have an interest in low impact pest management methods.

Given that growers are seemingly interested in low impact and sustainable growing methods, having a more concrete knowledge base surrounding natural wine production and corresponding management tactics may allow them to enter the growing and lucrative market. The young age and small size of these businesses allow them to be more maneuverable within the market and more readily able to adopt new sustainability practices (Liebert, Benner et al. 2022). This coupled with the locality and tourism of the New England wine sector may provide an opportune location for a natural wine industry. Further research into the efficacy and economic

sustainability of natural methods should be undertaken to bolster the unique marketability of New England Wine production.

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Weed Control Strategies in the Vineyard

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Since 2021 Flag Hill Winery has been operating a Red Dragon Vineyard and Orchard Flame weeder. The model is a GP 750, equipped with a 120 gallon propane tank, 2" ball hitch and four burners. The manufacturer suggests the equipment burns "4-6 gallons per acre" or "11-21 gallons per hour". These figures have not been verified but seem plausible.

The main goal of implementing the flame weeder in the vineyard is to move away from the use of paraquat for in season weed management. Although paraquat is an incredible useful, effective and convenient herbicide the literature and data suggest the ends do not justify the means. Paraquat is a systemic acute toxin for mammals, short term exposure can result in liver, lung, heart, and kidney damage. Long term exposure has been shown to result in Heart and Kidney failure as well as lung and esophageal tissue scaring. When paraquat comes in contact with aluminum it can produce highly flammable hydrogen gas.

Whether or not there is a correlation between paraquat exposure and Parkinson's Disease, is up for debate, but there is compelling data to support both sides. Regardless of the validity of the Parkinsons claims, there is enough evidence of other chronic and acute health problems caused by paraquat for it to be justified to be phased out of responsible farm systems.

The flame weeder does not kill the weed by burning it, rather the heat from the flame denatures proteins within the plant cells and burst the cell membranes. Plants are predominantly composed of water, which when heated, expands, rupturing cell walls, and killing the plant. Immediately after flaming a row, you will observe the plants have a flaccid, wilted appearance often accompanied by a change in color. This generally indicates that the flaming was effective.

Timing is essential for effective use of the flame weeder. The process is most effective when weeds are less than 6" high but ideally closer to 4". I have personally developed the belief that some residual moisture or morning dew increase the effectiveness of the process. Perhaps the moisture increases the thermal conductivity. Residual moisture also reduces the amount of smoldering, and thus reduces the number of calls to the fire department from well-meaning neighbors.

Some weeds are more resilient to the flame. Purslane and liverwort are the two plants that are most resilient to the heat. Developed tufts of grasses have also proved to be incredibly resilient to flame. There is less concern regarding the purslane and liver wort as they have minimal aesthetic impact and minimally compete with the vines.

The main goal of all weed management program is to limit weed competition with vines, keep the under-vine area aesthetically pleasing for customers and wedding photos. Limit the amount of weed based MOG out of our mechanical harvester.

Flame size and burner angle have a significant impact on function. Too large of a flame increases the possibility of melting hoses. Too small of a flame can decrease effectiveness. A poorly angled burner can decrease effectiveness and increase the possibility of melting hoses. A melted hose can result in a large uncontrolled flame. If one finds themselves this situation it is important to stay calm, turn off the left, right and master control switches and walk away until flames subside to a point where they can walk up to the tank and turn off the main valve.

The manufacturer suggests to operate this model at 3mph. The smaller the tactor the better the turning radius the easier it is to operate in the vineyard. When using a tractor adjust the height of your hitch when turning. When you come to the end of the row turn off the right and left control and take a beat until the flame subsides to just a pilot. If the operator is not being careful, they can easily create large unsightly burn marks in the grass when turning. After doing any work on hoses or valves, spray with soapy water to ensure no leaks are present. Always be listening and sniffing when operating to make sure nothing is getting squirrely.

Do not operate the tank when the volume is below 5%. Always keep control switches by your side. Be cautious when making sharp turns. Don’t wear clothing that can melt.

There are several potentially secondary effects of the flame weeder. Theoretically the flame weeding will kill seeds in the soil. Should help reduce the number of fungal spores under the canopy. Should incinerate insects and pest under the canopy.

Yield Ain't S*#t! It's Marketable Yield That Matters

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Mature blueberry bushes have a strong tendency towards over-producing and dropping berries prematurely. Left unmanaged and unpruned, bushes will produce thousands of inferior, unripened, miniscule berries, which are impractical to pick, process or sell. In this session we discuss certain practices for inducing ripening synchrony, increasing berry size, improving picking efficiency, inspiring return customers and focusing marketing efficiency…all to increase

Marketable Yield.

Everyone seems enchanted with volume or "yield." Blueberry agronomy researchers are obsessed with factors that increase yield. Growers love loaded bushes, assuming high numbers of flowers = plethora of potential berries = harvest success. U-pick customers assume a high crop load equals greater picking experience.

But yield alone is misleading. It is **marketable yield** that really matters. It is **berry quality** that's important. Achieving high marketable yield *by way of berry quality* is our competitive advantage in New England, where machine picking isn't cost-effective, and we can't compete with Michigan, New Jersey or Chile on volume. Our competitive advantage here in New

England is Quality and Customer Experience.

High yields don't really matter if berries are inferior in quality, too many or impractical to pick, dropped, spotted-wing infested or markets are undeveloped. Total yield matters only to the extent to which it potentiates marketable yield. NE Growers can strive to achieve a 100% marketable yield of every crop grown.
The formula for marketable yield is:

MY = Y x M

Or**, M**arketable **Y**ield = **Y**ield x **M**arketablity

whereas **MY** can be expressed as lbs sold/season or % of your total crop you actually sell.

This session centers around factors that contribute to **M**arketability:

Marketability = Inspired Pickers x Berry Quality x Marketing Efficiency

Inspired Pickers

This factor is the human resource on the farm. It is a complex, holistic picture of the human condition – what physical, mental and even spiritual state pickers are in when they approach your fields. It is the human experience in the berry patch, and you can enhance it in so many ways.

From a purely economic perspective, happy, inspired pickers do a better job at sustaining high pick rates no matter what weather rolls in. Happy, inspired pickers are also more likely to return, whether as a u-pick customer or as a long-time employee at your farm, **thereby increasing their understanding of your operation and their skill in picking over longer terms**.

Some examples of things you can do to improve the human experience in the berry patch:

- Integrate art and music
- Incorporate breaks
- Pay staff as much as you possibly can pay-- by the hour, not by the bucket, and provide incentives for harvesting consistency and quality

Berry Quality

A whole host of agronomic practices factor into berry quality, such as achieving optimum fertilization rates, mulching, irrigation, etc. We don't have the time to go into these, but we can touch on several often-overlooked characteristics of blueberry quality and **hammer home the point that pruning enhances all of them.**

- Pruning increases berry *synchrony* or the tendency for more berries per cluster or per bush to ripen at the same time. This greatly increases the chances that fully-ripe, quality berries will get picked instead of drop or end up spotted-wing infested, ultimately leading to better Marketable Yield.
- Pruning might decrease berry quantity but increases berry *size*. Larger blueberry size remarkably increases picking efficiency and wows your customers.
- Pruning increases berry mouth feel and *flavor*, because it results in a greater percentage of photosynthates focused into each berry. This also boosts anthocyanin content, "pop-in-your-mouth-ness," firmness and shelf life.
- Pruning increases "*pickability*", an under-appreciated quality factor. Remember, yield isn't useful if you have to perform contorted yoga postures just to pick your berries. Get them above knee height, get them out into the open air and readily accessible to your pickers.

Marketing Efficiency

We can share one concept that has worked really well and that is standardization of product quality, availability and customer service **attracts a steady base of return customers**. It is easy to sell just one pint of blueberries to someone, but our aim is multiple visits and contacts. Efficiency is about decreasing effort to achieve better outcome. Return customers basically

market your berries for you, which increases demand for your product with very little marketing expense on your part.

Return customers look for:

- a consistently available (or delivered) high quality product
- a reasonable price, but there is a subjective range depending on how good a job you do at the first bullet directly above
- other value-added experience beyond fresh berries. In other words, keep producing and marketing the same excellent quality berries year after year in a completely accessible manner, but stir things up a bit. Do a tasting here and there of a new product, surprise your customers with unique and joyful blueberry creations or experience.

In conclusion, the potential for marketable or consumable yield starts with raw yield but goes way beyond it. Having enthusiastic pickers, premium berry quality and loyal demand for product greatly increases marketable yield, a practical barometer of success for any blueberry producer.

Research Update on Managing Spotted Wing Drosophila

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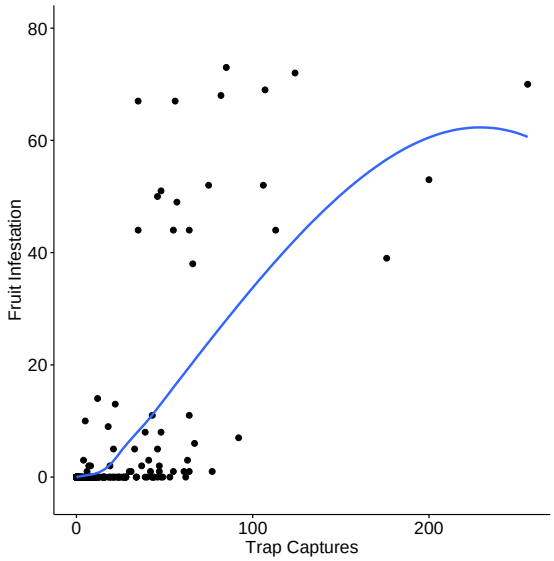
Spotted Wing Drosophila (SWD) has been causing problems for berry growers in the Northeast for the past 10+ years. In the intervening years since its first detection in 2011, the research community has learned a tremendous amount about its biology and management such that the industry has moved from a crisis situation to a more or less manageable problem. However, insecticides remain the primary method of control, with their associated costs. Indeed, insecticide resistance and control failures in the field are occurring in California and although control failures have not been documented in the eastern US, some SWD populations are showing elevated levels of resistance to some compounds. There is a great need for continued research into SWD and alternative management strategies.

We divide our SWD research objectives into three broad categories. 1) Understanding SWD biology, 2) Testing short-term management tactics, and 3) Investigating long-term management solutions. For this presentation I will provide updates on some of the research in my lab in the areas of short and longer-term management.

Pest monitoring is foundational to the implementation of a successful IPM program. Monitoring adult SWD in the Northeast makes the most sense in early to mid-summer, when SWD adults become active, to help determine when to initiate control measures. This is because overwintering survival of SWD is low, but variable, in the Northeast and in some years early to mid-season berries may escape SWD infestation. For crops like summer raspberries and early to mid-season blueberry cultivars, adult monitoring can be very useful. Typically, later in the growing season, SWD populations are well-established and all berry crops with ripe fruit are vulnerable. At this time adult monitoring is probably less useful, although monitoring larval infestations could provide important information on the need for control measures. With regards to adult monitoring in early to mid-season, wet traps, where a food-based lure is used to attract male and female flies to a cup type trap where they are drowned in a water solution, is currently the most common method. However, it is time consuming to sort through the insects captured in wet traps and it takes equipment and training to identify and count SWD, especially female flies. As part of a regional and national effort, we have been assessing dry sticky card traps to quantify captures of male SWD in the field and determine how well captures relate to infestation risk. The dry traps are much more efficient to process than wet traps. In blueberries, male SWD captured on sticky card traps seem to provide similar information as male and female



SWD captured in wet traps. We are still examining the relationship between number of males captured on cards verses infestation levels. Here is a figure from NY data in 2021 comparing cumulative captures of males on sticky traps with cumulative infestation of berries. These results indicate that each male caught in a dry trap roughly translated into an infestation rate of one egg per 120 nearby berries, although more data are needed. Our hope is to combine efforts with Miguel Gomez, Ag economist at Cornell, to optimize the use of adult and larval monitoring for different production systems and marketing strategies.

For susceptible berry crops, insecticides are the main control method used by commercial growers to manage SWD. Chemical control has generally been effective, although there are economic, environmental and potentially human health costs associated with frequent and widespread use of insecticides. For the past couple of growing seasons, we have investigated applying insecticides below the crop canopy instead of in the canopy as a way to mitigate negative impacts on beneficials. The results so far are intriguing. Using cages over small sections of fall raspberries, we found that soil applied insecticide provided about the same level of control of SWD as the insecticide applied to the canopy. We obtained similar results for sections of open field raspberries. We are still working through the data, including the impact on beneficial arthropods, but it raises the possibility that one way to mitigate the negative impacts of insecticides is to direct the sprays to the ground below the canopy.

As noted above, SWD resistance to one or several classes of insecticides is a major concern for researchers and growers alike. To potentially reduce industry reliance on insecticides for managing SWD, we have been working on several alternatives. I want to give an update on two research areas here: manipulation of behavior with repellents and attractants and classical biological control. We have been interested in understanding the host finding ecology of SWD both to develop better attractants for monitoring and/or attract and kill and for finding repellents to discourage colonization and/or egg laying. We have done the most work with repellents. I will show some recent research on using 2-pentylfuran (2pf), a volatile organic compound produced by microorganisms that is used as a food additive. We discovered it while looking for attractive odors associated with fermentation. We have shown in the lab that adults avoid attractive baits when 2pf is present at sufficient concentration and both in the lab and field that 2pf can significantly reduce fruit infestation. We are currently working with a pest management company to see if we can develop a cost-effective method for applying 2pf at larger scale. There are many hurdles to overcome, however, before we might have an effective commercial product. Other research groups are investigating other candidate chemicals that could be developed into repellents.

Biological control is another research area we have dedicated significant effort, especially in the last year or two. Natural enemies native to the USA, such as parasitoids, unfortunately cause very little mortality to SWD. There is a tremendous need, therefore, to find ways to increase the impact of natural enemies in order to reduce SWD populations, not just in susceptible crops, but importantly, in the landscape which is full of alternative SWD host plants. Explorations in Asia conducted by our colleague Dr. Kent Daane, University of California, and others have discovered several larval parasitoid wasps that cause significant SWD mortality. Over several years of screening candidate parasitoids in quarantine labs in the US, the team settled on a species of wasp with the scientific name of *Ganaspis brasiliensis*. Here is a closeup photo of an adult female *G. brasiliensis* inserting an egg through the skin of a blueberry and into a SWD larva. Here is a professionally produced video you might enjoy watching on SWD and *G. brasiliensis* with incredible closeup photography (https://youtu.be/MJsI50wQELU).

Ganaspis brasiliensis, a parasitoid of SWD. Photo by Kent Daane

After several years of review, a permit from the USDA was granted in 2021 to release *G. brasiliensis* in the USA. Working closely with colleagues at Rutgers University (Dr. Cesar Rodriguez-Saona) and the University of Maine (Dr. Philip Fanning), we are addressing three objectives in our project: 1) Develop an efficient method for rearing *G. brasiliensis* in the laboratory for release into the field, 2) Assess whether *G. bransiliensis* can become permanently established in New York and other areas in the US, and 3) Evaluate how well *G. brasiliensis* overwinters in northern climate zones. In 2022, we released over 500 adult wasps at each of four berry farms in central NY. Similar releases have been done around the USA. Sampling at release sites this fall suggests some initial success in getting *G. brasiliensis* established but the real test will be if we can find them next spring. We plan to release at these same sites again next year and the following year. Typically, it takes several years to establish a classical biological control agent so it will take some time before we learn whether *G. brasiliensis* does well in the Northeast and whether it helps bring down SWD populations thereby reducing the need for chemical control.

We are very appreciative of financial support of our research from several sources including USDA Crop Protection Pest Management Program, USDA Specialty Crops Research Initiative, NYS Department of Agriculture, NY Farm Viability Institute and the NYS Berry Growers Association. And we want to thank berry growers who are working with us on these projects.

How Gleaning Can Fit Into Your Operation

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Whether you are an existing farm or an aspiring farmer, gleaning can provide dynamic value to your farm business. Tim Taylor and Mikey Van Siclen discuss the partnership between Crossroad Farm & Willing Hands, as well as the many benefits farms can experience through gleaning.

Willing Hands' mission is to recover fresh food in order to reduce waste, improve health, and provide reliable access to nutritious food for our neighbors in need. We believe in a community where everyone can enjoy nourishing, fresh food regardless of economic status or personal circumstance.

Gleaning – a form of food recovery where volunteers pick the leftover produce from your farm's harvest – is central to our mission. We believe that every community has a shared responsibility to reduce waste and contribute to a sustainable environment, and our partnerships with local farms help us achieve these goals.

With food prices on the rise, the number of food-insecure families is increasing as well. Gleaning helps us ensure that food grown by local farmers does not go to waste. Instead, it can be enjoyed by our community members who otherwise would not have access to this fresh, local produce.

Over the years, Willing Hands has become one of the most successful hunger relief and food recovery organizations in New England. Our concept is simple and effective:

1. Our drivers pick up fresh produce, dairy, eggs, meat and bread from food donors including farms, grocery stores, wholesalers, and restaurants.
2. Volunteers glean leftover produce from local farms and grow produce in our four Willing Hands gardens.
3. Our drivers deliver this food seven days a week, year-round, to 80 recipient organizations across the Upper Valley, including food shelves, shelters, and senior housing facilities.
4. Our neighbors get access to free, healthy food year-round.

When local food stores and wholesalers have excess food which is at risk of going to waste, Willing Hands drivers pick it up and bring it back to our facility in Norwich, Vermont. There, volunteers check it over, compost anything which is not in good condition, and store it briefly in our coolers until it packed back onto our trucks for delivery around the Upper Valley.

Willing Hands relies on a large network of volunteers to grow produce in our four gardens and to glean fruits and vegetables from local farms. While gleaning and food recovery are central to our mission, we also run several volunteer-powered gardens that help us grow specific crops (like greens during the summer and root vegetables in the fall) so that we can continue to provide a balanced supply of produce year-round.

Willing Hands is a member of the Vermont Gleaning Collective and New Hampshire Gleans.

Crossroad Farm is a 56 acre diverse vegetable farm located in the Upper Valley in Post Mills, Vermont. We have 2 stands and a number of direct marketed wholesale customers including a food co-op, restaurants, and summer camps. Additionally, we sell at a substantial discount to the Upper Valley Haven, a non-profit organization committed to delivering essential human services to the people of the Upper Valley.

As most of you know it is difficult to compete with California as to prices of our vegetables. Quality is a different story, but competitive prices are always a challenge. Over the years we have tried different ideas to make access to our produce more available to those in need. For one reason or another none of our methods were completely satisfactory. In 2005, we heard about a new organization which was recovering food that was otherwise headed for the dumpster. We got in touch with Willing Hands and started giving them harvested vegetables for which we had no market. This worked well but was very irregular. Whether we had any food to donate depended upon having extra vegetables and having harvested them ourselves. Often the decision would be made to just leave them in the field and return them to the soil.

In 2008, Willing Hands started a new program where volunteers would come to a farm and harvest the extra produce right out of the fields. This made it much less burdensome for the farmer. All I had to do was contact Willing Hands when we had extra vegetables and they would come get it. However, even taking the time to decide if you have extra produce can slow a busy farmer to the point of not calling. That's when I suggested that we set up a regular time every week to come. There is almost always something available. This has worked out well and made our outreach to those who are food insecure more consistent.

The positive publicity our "generosity" has received alone makes our donation worthwhile and I encourage all of you to give it a try. Our partnership with Willing Hands has extended our farm's reach both geographically and economically. By allowing volunteers to come to our farm and harvest, we invite new potential customers into our fields and donate this harvested food to our neighbors who otherwise could not afford our produce. This synergistic partnership represents the essence of a sustainable community where nobody remains hungry.

Cover crop considerations prior to and following root crops

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Root crops and alliums have several management goals that are particularly important and that cover crops can help meet.

Most root crop and allium seedlings are small for a long time so there is ample opportunity for weed seedlings to grow and compete, and it is difficult to cultivate without damaging them. In this situation, the most important role for a cover crop is to reduce the weed seed bank.

Reducing the weed seed bank a meaningful amount means constant vigilance against weeds going to seed. Planting cover crops any time or anywhere soil would otherwise be open is a valuable practice.

Soil health, in particular friable soil, is also valuable for weed management because it gets the crop seedlings off to a fast start to better compete with weeds. A friable soil is also much easier to cultivate for precise weed control. If the soil aggregates flow around the cultivator blade, the action is mostly on the weed. It is also easier to steer cultivators close to the crop row without wiggling into it.

Root rot prevention is an top goal with root crops. Cover crops can help reduce periods of excessive soil moisture that is conducive to root rot. Some cover crops also suppress root rot organisms directly. The former is probably the more important mechanism. Again, friable soil with good internal drainage is the means of creating that condition, and improved soil aggregation through cover crops is the practice.

For harvest, the soil that will let go of the crop is valuable. For this management goal as well, a friable soil is an important mechanism and aggregating cover crops are the practice.

Aggregation is most promoted by sod-forming grasses such as annual ryegrass. Because the roots are so dense, a ryegrass cover crop needs to break down for a long time, and is best used half a year to two years before the vegetable is seeded. Buckwheat is an excellent short-term aggregator that can be growing in the previous season and break down completely.

Weed suppression really depends on the three keys to successful cover crops;

- Fast Start
- No Gaps
- Kill on time

In the summer buckwheat is the best weed suppressor. Crucifers take that role for fall, providing good direct-seeding conditions in the spring.

Disease suppression is most likely to come from crucifers. Biofumigation practices are not possible here, but may also be unnecessary if there is a good root system.

Managing Key Diseases of Onions: Stop the Rot!

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

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

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

Management of Stemphylium leaf blight and purple blotch includes a three- to four-year crop rotation to allow the crop residue to decompose, optimizing crop nutrition to reduce plant stress, weed management in and around fields, and use of fungicides under high disease pressure. In New York and Ontario, Canada Stemphylium leaf blight resistance to fungicides in FRAC groups 2, 7, 9 and 11 has been reported causing a reliance on fungicides in FRAC group 3. Resistance has not been reported in PA however, it is important to rotate among FRAC groups to reduce the potential development of resistance. To-date, biopesticides have provided limited efficacy against these diseases.

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

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

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

temperatures. Reducing exposure to high temperatures and storing in low humidity will help manage black mold.

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

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

Burkholderia spp. are soilborne and known to cause the bulb diseases sour skin and slippery skin. **Sour skin** is characterized by a rotting of the outer scales and has a very foul vinegar odor as a result of colonization by secondary organisms. The affected scales will turn reddish-brown to

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

Winter Cover Crops in High Tunnels; home grown fertilizer and soil health

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Recent studies reveal a rapidly changing economic reality for vegetables farmers. Potassium and phosphorus fertilizer indices nearly doubled over the last year, and nitrogen in some cases, tripled! Analysts predict that farmers will continue to face much higher fertilizer prices in the coming season, as higher natural gas prices further increase the cost of nitrogen. However, ongoing research by Cornell Cooperative Extension contributes to farm sustainability by reducing reliance on shipped-in nitrogen and decreasing input costs.

Why Tunnels and Nitrogen?

To meet the year-round demand for locally produced food, Northeast vegetable farmers have embraced protected agriculture to extend their growing season, improve yields, and enhance crop quality. High tunnels (soil-based greenhouses) are a protected agriculture technology that help farmers achieve these goals. These high yielding sites on the farm demand high nutrient inputs, in particular nitrogen.

However, in pursuit of nitrogen farmers often over apply compost and fertilizers. Nutrient imbalances, disease and decreasing crop yields follow, restricting economic and environmental sustainability for high tunnel farmers. In previous research we have documented that 94% of sampled high tunnels had excessive phosphorus, 66% with excess soil pH, a majority of foliar analyses indicated excess nitrogen in the crop; all the while less than 10% were implementing cover crops.

To support continued growth of this industry in the face of climbing fertilizer prices and soil sustainability, Cornell Cooperative Extension researched practices that high tunnel growers can adopt to better manage soil fertility and improve soil health. Including winter cover crops in high tunnel tomato rotations may be a way to scavenge leftover nitrogen and/or fix nitrogen.

Methods

We trialed two cover crop species: Austrian field peas and Triticale at a cooperating farm Yates County, NY. Austrian field peas provide the benefit of nitrogen fixation through their relationship with Rhizobacteria. The combination of a grain with the legume is often considered beneficial for the germination and establishment of the legume. Triticale itself may produce more biomass than other winter grains such as wheat or barley and is less likely to produce volunteer plants. For this project, cover crop trials occupied two high tunnels, repeated two consecutive years.

For this project, cover crop trials occupied two high tunnels at Maple Lane Produce. In the fall, "Fridge" triticale and "Maxum" field peas were acquired through the Territorial Seed Company.

Subsamples were mixed thoroughly and submitted to Dairy One Agronomy Services (Ithaca, NY) for Modified Morgan analysis, nitrate nitrogen, pH, and organic matter. Strip plots of triticale and a triticale/field pea mix were planted in both tunnels. "Verdesian Guard-N" legume seed inoculant (Johnny's Selected Seeds) was applied to field pea seed prior to broadcasting. A third strip of bare soil was included in the trials as a control. Strip plots measured 15 feet long by 30 feet wide. Cover crop seed was watered in using overhead sprinkler irrigation. "Tunnel 1" cover crops were planted on October 11 and "Tunnel 3" cover crops were planted on October 25. Agribon AG-19 Row cover was added to half of the plots late December and remained until incorporation of the cover crop. Over the course of the winter/early spring, cover crop foliar biomass was sampled once a month and measured for fresh weight. A subsample of each plot was submitted to Waters Agriculture Labs (Owensboro, KY) for foliar nutrient analysis. The remainder of the samples were dried in an oven to obtain dry weights. The cover crops in Tunnel 1 (early planting) were mowed and incorporated on March 17. The cover crops planted into Tunnel 3 (late planting) were mowed and incorporated on April 22.

Figure 3. Fall of 2022 has produced our largest cover crop yet!

Our Knowledge Gain from this trial: **Plant early**. For every treatment, the earlier seeded cover crop yield more biomass compared to the later seeded crops. The smallest difference was in the "Triticale with row cover" treatment. For all other treatments, the earlier seeded crop yields almost 2 to 3X as much biomass than the later seeded crop.

Triticale + Field peas mix often yields more biomass. Across both tunnels, we saw the triticale and field pea mix outperforming the triticale in both covered and uncovered settings. The field peas were planted 53% of the recommended rate of 150 lbs per acre. Most

cover crop resources recommend that the percentage of legume in a mix with a grass be increased to account for how vigorous grasses can be. While actual seeding rate recommendations vary widely depending on the species, late plantings, broadcasting vs. direct planting, the project team went with a lower rate of field peas/Acre. We felt comfortable trialing the legumes at a lower rate given that we're trialing cover crops in a new environment and legume seed is pricier than grain seed. Furthermore, higher rates for broadcasting are typically meant to account for poorer germination due to varying soil moisture and lack of irrigation and pest pressure. The fact that the Triticale and Field Pea mix is outperforming in terms of biomass may hint that growers can plant field peas at a lower rate in a high tunnel setting.

Row cover can increase biomass. At both seeding dates, all treatments that had row cover applied yielded more biomass. The impact of row cover on biomass production was much greater in the later seeded planting in Tunnel 3, compared to the earlier planting. This suggests that if growers plant early, the addition of row cover may not be necessary to produce a lot of biomass. Alternatively, if growers seed their cover crop late, adding row cover will be instrumental in making up for the lost time.

Early plantings + row cover = higher N contributions. Estimated nitrogen contribution is higher in earlier seeded treatments. It is also higher in treatments that received row cover. The highest estimated contribution is 102 lbs./Acre in the early planted, triticale and field pea mix that received row cover application. With a Cornell Vegetable Guidelines recommend rate of 125-150 lbs. of N/ac, our project demonstrated tremendous potential to reduce input costs.

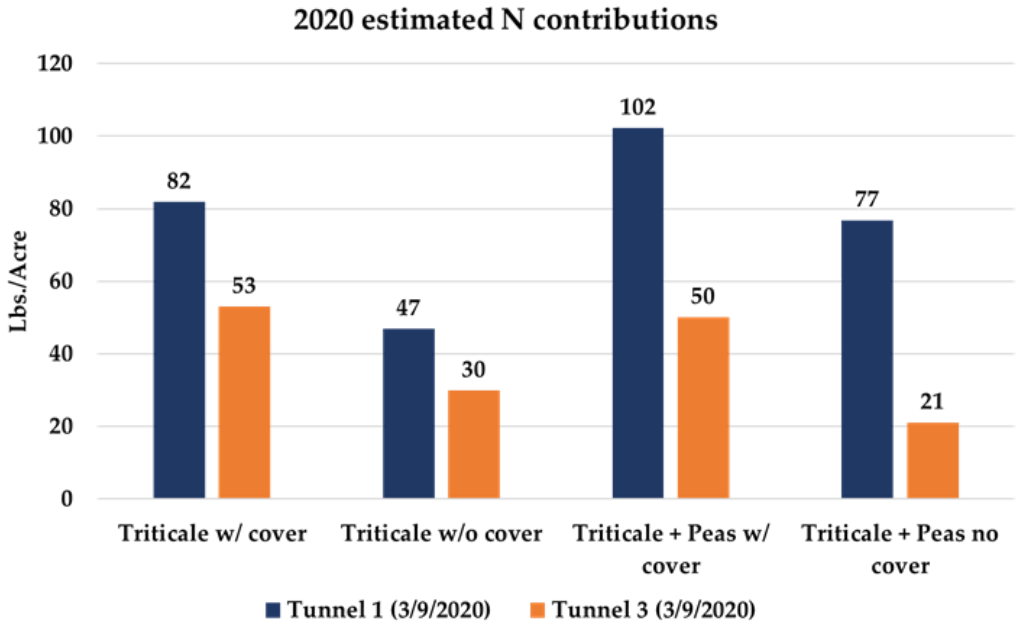

Figure 4. Estimated nitrogen contribution of winter cover crops in a high tunnel with and without row cover for two different planting dates.

We are very grateful to the NY farmers that are so collaborative to advance our knowledge in this topic. The work was funded by a USDA Specialty Crop Block Grant, administered by the

New York Farm Viability Institute. We used this project to leverage continued support from the USDA NRCS Conservation Innovation Grant for a 3-year currently underway.
Please check out some of our project videos!

https://youtu.be/sGWbC_CCojs

https://youtu.be/eLK6jnc0YzA

https://www.youtube.com/watch?v=m94bE5DV5SI&t=10s

Increasing Fruit Set and Yield in High Tunnel Tomatoes

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The Problem: I have been growing high tunnel (HT) tomatoes in Maryland for the last 18 years and have noticed that there are always more flowers than tomato fruit. Usually a cluster consists of 5-8 flowers, but only 2-5 develop into fruit (the overall average is between 40-60% of flowers into fruit). This does not happen just to HT tomatoes but also to field grown tomatoes. Much of this fruit deficit is due to poor pollination and fruit set. Tomatoes are usually self-fertilized with their pollen being well hidden. It takes some decent wind or a bumble bee to come along and vibrate (known as buzz pollination) the tomato flower in order for the pollen to be released. In the field this can be accomplished by the action of wind or by insects visiting the tomato flowers. But in a HT that may be closed up during the early flowering period of tomatoes because it is overcast and cool it is much more difficult to get the needed vibration for the flower to be pollinated. But even if the sides of the HT are up it can still be difficult to get enough air movement into the center of the HT to have effective pollination.

So, I was looking for a simple easy method of increasing pollen release from tomato flowers to see if that increased the number and or size of tomato fruit being produced and if it did could the plant support nutritionally the increase in tomato fruit (measured as fruit quality). There are a couple of ways to increase pollination in tomatoes; one way is to use bumble bees to perform buzz-pollination, but I could not have the bees pollinate only certain tomato plants nor have them visit plants a differing number of times to test how important extra pollination was. The other way is by vibrating each flower by hand, but this method is laborious and time consuming. The way in which I tried to enhance pollination and fruit set was by increasing the action of wind pollination by using a leaf blower.

Methods: I conducted this study for 2 years. The first year of the study only one HT was used while in the 2nd year 2 HTs--i.e., HT-A and HT-B, were used. One HT was on the eastern shore of Maryland while the other was on the western shore of Maryland. I'll be reporting only on the 2nd year of the study as it shows the same results as the first year and I was able to reduce the number of variables I was looking at. Four different cultivars of tomatoes were used in both HTs, 2 hybrids (*Mt Fresh+* and *Crista*) and 2 heirlooms (*Cherokee Purple* and *Big Beef*). I used a Craftsman 235/150 mph electric blower. An 'enhanced pollination treatment' consisted of taking the leaf blower and placing it on low (150 mph) with the end of the blower 2-3 ft from a plant moving it back and forth and up and down concentrating the movement in the area of the flowers. Plants were treated either 0, 2, 4 or 6 times a week and for either 0, 5, 10, or 20 seconds with the blower. Treatments started 5-days after the first flower cluster appeared and were treated for 4 weeks. There were 4 replications of each treatment, 5 plants per rep.

Results: Overall it was a good year for HT tomatoes in these trials. At both HT sites - A and B using the leaf blower at least 4 times a week resulted in significantly greater fruit set and yields than not using the blower (Tables 1 and 3). The pollination enhancement increased overall yields

by 44% in HT-A and 60% in HT-B vs. the control. The percentage of culls was significantly reduced when tomatoes were treated 4-times a week in HT-B and when treated 2, 4 and 6 times a week in HT-A.

Average fruit size was significantly greater when pollination enhancement techniques were used for 2, 4 or 6 days a week vs no enhancement in HT-A and HT-B (Tables 1 and 3). There was at least a 40% increase in the average fruit size in both HTs when plants were treated for 4-days a week vs when they were not treated at all.

There was no significant difference between a plant being treated for 5 secs vs being treated longer (Tables 2 and 4). Treating a plant for 5, 10, or 20 seconds resulted in a significant yield increase compared with not treating the plant at all.

As far as cultivars are concerned the 2 hybrids did better--responded more favorably to the pollination enhancement technique compared with the two heirlooms. The two hybrids had a yield increase of ~60% vs no enhancement while the heirloom cultivars had yield increases of ~40% vs no enhancement techniques. High tunnel B generally had better yields than high tunnel A, but they were not significant.

Discussion: Overall yields were good in these two HTs compared with previous seasons. Normally I would have expected 19.6 lbs/plant in these HTs, but instead got 21.8 lbs per plant (this may have been due to inadvertent extra wind pollination from the blower on the control plants). Research in the eastern United States has demonstrated that the yield per plant from a HT tomato should be between 20 and 30 lbs per plant. The average increased to as much as 33.7 lbs per plant with the pollination enhancement technique. It would seem that the low end of the scale that I was at before was mostly due to poor pollination in these HTs. By enhancing the pollination I was able to increase my yields by as much as 72%. The pollination enhancement technique also improved fruit quality by reducing the percentage of culls and increasing the average size of fruit.

This also demonstrates one of the concerns I had about the technique in that if fruit set was increased and plants were supporting more fruit per plant would they be able to size those tomatoes and would the tomatoes have good quality and the answer was yes to both questions. We did not add any extra nutrients to either HT compared with how we normally fertilize. We may have added a bit more water than we normally do, but this also could be because of the very dry conditions in June.

While this technique certainly would not be for everyone it does demonstrate that HT tomatoes are often underperforming because of a lack of good pollination. This could be corrected for by using bumble bees or hand pollination techniques. But by using an air-blower increasing fruit set could be carried out very easily in a HT by just about anyone that can hold and point a leaf blower. The plants would need to be treated for 5-10 seconds at least 4 times a week for there to be a good possibility of yield and quality enhancement. Treating the plants longer than 20 seconds ended up decreasing yields compared with doing nothing (data from year 1). Plants could undergo this enhancement technique in the early part of the season when the HT sides are often down. This technique did appear to work better on the first 7-8 fruit clusters the plant

produced vs using the technique on later fruit clusters. This technique should not be used if your HT tomatoes are low in any nutrient by the first harvest or you often have fruit ripening problems with later harvests.

Table 1. Number of times per week plants treated-HT-A

No. days/wk treated:	0	2	4	6
Yield (lbs/plant)	21.5a	22.7a	30.2b	31.8b
% fruit that were culls	8.4a	6.5b	4.5c	4.2c
wt. of average fruit (oz.)	7.05a	8.85b	10.34c	10.51c

Means within a row with different letters are significantly different at the $p \leq 0.05$ level

Table 2. Length of time plant was treated HT-A

Length of time plants treated (sec)	0	5	10	20
Yield (lbs/plant)	23.4a	29.7b	27.6b	25.1b

Means within a row with different letters are significantly different at the $p \leq 0.05$ level

Table 3. Number of times per week plants treated-HT-B

No. days/wk treated:	0	2	4
Yield (lbs/plant)	22.1a	26.4b	33.7c
% fruit as culls	12.6b	8.7ab	6.3a
wt. of average fruit (oz.)	7.12a	8.36b	9.14c

Means within a row with different letters are significantly different at the $p \leq 0.05$ level

Table 4. Length of time plant was treated HT-B

Length of time plants treated (sec)	0	5	10	20
Yield (lbs/plant)	18.8a	26.3b	25.2b	26.8b

Means within a row with different letters are significantly different at the $p \leq 0.05$ level

Grapevine Trunk Diseases

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Grapevine fungal trunk diseases, from Esca to dead arm, are very destructive worldwide. Trunk diseases are less obvious than foliar and fruit diseases but they can infect the perennial wood, grow unchecked and become worse as a vineyard ages, resulting in significant dieback and decline over the years. There is a strong demand for novel disease management strategies. In order to improve control of grapevine trunk diseases, we need to better understand them.

1- What are fungal trunk diseases of grapevine?

Eutypa dieback is the best known of the fungal trunk diseases in Northeastern American viticulture. It is diagnosed by the characteristic wedge-shaped area of dead tissue when cutting part of the permanent woody structure of the grapevine. However, there are many unrelated fungi that can cause trunk diseases on grapes (Bettiga, 2013):

(1) Species in the Diatrypaceae family including Eutypa lata the causal agent of Eutypa dieback;
(2) 21 species in the Botryosphaeriaceae family causing Botryosphaeria dieback and comprised in the genera Botryosphaeria, Diplodia, Dothiorella, Guignardia, Lasiodiploidia, Neofusicoccum, Phaeobotryosphaeria, and Spencermartinsia, have been isolated from grapevine dieback symptoms, some of which cause a wedge-shaped canker indistinguishable from Eutypa dieback;
(3) Species in the genus Phaeoacremonium and Phaeomoniella, the causal agents of esca or black measles and Petri disease;
(4) Species in the genus Cylindrocarpon, the causal agent of black foot disease, a root and trunk disease.

This list of fungi is not exhaustive as additional species are frequently being isolated from wood cankers and branch dieback worldwide. Each fungus has its own biology and therefore should theoretically be managed differently.

2- Do you have trunk disease in your vineyard?

• On perennial parts:
- o Wedged-shaped perennial cankers could be an indication of either Eutypa dieback or Botryosphaeria dieback. (Figure 1)
- o Vascular streaking could be indicative of Esca, Petri disease, Botryosphaeria dieback or black foot disease. (Figure 1)

• On fruits:
One of the most noticeable symptoms of Esca occurs on the fruits and inspired the common name “black measles”. Superficial dark spots develop on the berry epidermis between fruit set

and ripening. If the spots appear early in the season, the dark spots coalesce, causing berries to shrivel and entire clusters to dry on the vine.

• On leaves:
Leaf symptoms of Esca usually develop on cane with symptomatic fruits. Leaves show interveinal discoloration and dark-colored cultivars display red-margin around the dead interveinal areas.

• On shoots:

- o Flag shoot: For Esca, during the active seasons, the first symptom to appear would be a shoot tip dieback where the entire tip appears blighted.
- o Stunted shoots: Shoot symptoms of vines help separate Botryosphaeria from Eutypa diseases. In the case of Eutypa, shoots have short internodes and show stunted spring growth with leaves small cupped and chlorotic. In the case of Botryosphaeria, a given cordon could show a total absence of spring growth and normal healthy development of shoots.

3- Preventing and managing fungal trunk diseases of grapevine.

Prevention:
Plant material should be inspected before planting and young vines should be properly handled during their establishment. Abiotic stress (water-stress...) could be a predisposing factor. Fungal trunk diseases infect primarily through pruning wounds. In young vineyards (< 5 years old), prevention starts by avoiding infections of new pruning wounds. This can be done by either not pruning during a season when pruning wounds could get infected or by practicing double pruning (i.e. pruning when there is a chance of infection and pruning later on when infection are less likely to remove the part of the trunk that might have been exposed to trunk pathogens). Pruning wounds can also be protected with either fungicides that are labelled for the dormant season or non-fungicide materials that create a physical barrier against infection. Many grape growers in cool climate viticulture have renewals such as double trunk. This practice could be useful in a case where a canker would have expanded significantly low in the perennial wood in one of the trunk and removal of that trunk is necessary.

Eradication:
Preventative measures reduce the chance of new infections but do not eradicate diseases. If a vine is infected, one should prune any perennial part with cankers 4 or 5 inches below the visible canker and destroy the wood by burying or burning. Because the fruiting bodies of fungal canker pathogens can be found on dead wood, it is essential to destroy it. Sanitation creates large wounds; therefore it is recommended to apply a pruning-wound protectant if conditions are conducive to disease when pruning (i.e. rain) or one expects the inoculum to be present. In New-York state, a concentrated solution of Topsin-M 70 WSB (3.2 oz/gallon of water) can be applied to pruning wounds where extensive cuts have been made due to the presence of a canker and therefore potential surrounding inoculum is expected (Wilcox, Wayne, 2015).

4- New findings on pathogenesis from our research with implications for control (Perez-Gonzalez et al. 2022)

Eutypa dieback and Esca complex require, or are enhanced by, fungal consortia growth which leads to the deterioration of the wood tissue in the grapevine trunk; however, pathogenesis and the underlying mechanisms involved in the woody tissue degradation are not understood. We examined the role that the consortia fungal metabolome have in generating oxygen radicals that could potentially play a role in trunk decay and pathogenesis. Unique metabolites were isolated from the consortia fungi with some metabolites preferentially reducing iron whereas others were involved in redox cycling to generate hydrogen peroxide. Metabolite suites with different functions were produced when fungi were grown separately vs. when grown in consortia. Chelator-mediated Fenton chemistry promoted by metabolites from these fungi allowed for the generation of highly reactive hydroxyl radicals. We hypothesize that this mechanism may be involved in pathogenicity in grapevine tissue as a causal mechanism associated with trunk wood deterioration/necrosis in these two diseases of grape. Further exploration of this mechanism could potentially open new alternatives to better understand these diseases and ultimately open paths to explore the targets for the development of treatments to prevent or limit yield loss in vineyards.

Figure 1. (A) Cross-section of grapevine trunk with necrosis and wood degradation typical of Eutypa dieback. **(B, C)** Cross-section and longitudinal sections, respectively, of grapevine trunk with necrosis and wood degradation typical of Esca disease. (Perez-Gonzalez et al. 2022)

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Vineyard disease management that works:
Using IPM to minimize pesticide applications while managing diseases in cold climate winegrape varieties

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Integrated pest management (IPM) is a sustainable approach to managing pests which combines biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. IPM is based on knowledge about the biology of the different pests (including insects, diseases, vertebrates, and weeds), how they interact with the crop, and how the environment affects this interaction. IPM is also information-driven including information on the development stage of particular pests, size of the pest population (i.e., whether threshold levels have been reached that require action), and whether there are sufficient natural predators in your vineyard which might manage a pest situation without your intervention.

Pure *Vitis vinifera* cultivars evolved in the warm, dry Mediterranean, southern Europe, and Southwest Asia region, an environment that does not generally support fungal growth and thus those varieties tend to have little resistance to diseases when grown in humid eastern North America. The cold-climate winegrape cultivars grown in much of New England contain significant amounts of parentage from native grape species that co-evolved with many of the pests, especially diseases, that exist in the region. As a result, they trend to have high levels of disease resistance compared to *V. vinifera* grapes. This allows growers to use a disease management program that relies much less on fungicide applications than one developed to protect susceptible Eurasian cultivars.

Is IPM organic? It can be depending on what management tools and options are used. IPM is an *approach* to managing pests that is compatible with sustainable agriculture and organic agriculture. However, because some spray materials certified for use in organic systems have lower efficacy than synthetic materials, adequate organic management of certain diseases will require strict attention to vineyard sanitation and may require more spray applications than an IPM program that does not limit the use of synthetic materials. *The spray program outlined below is generally <u>not</u> acceptable for organic production.*

IPM is only one area of management, albeit an important one, that will impact vineyard production and profitability. Quality wine requires quality grapes and adequate pest management is an important factor in the production of quality grapes. There are numerous diseases and insect pests which will need to be managed effectively during the growing season.

The following is an initial strategy to manage various diseases and insects that can significantly impact grape production. As the vineyard matures, insect and disease inoculum will likely increase which may increase need for intervention. This guide is thus not a prescription, but rather should be adapted based on vineyard conditions and your experience as a grower. In order to customize this program, keep the following practices in mind:

1. **Read**. IPM concepts include understanding crop and pest life cycles; collecting and applying weather data to biological models; scouting the planting for signs of disease and insect pests; practicing good crop management to reduce pests through physical or cultural means; and properly applying chemical controls when deemed necessary. IPM does not provide a recipe for pest management, but rather demands that growers understand the particular needs of the vineyard and best ways to manage them. A good primer on understanding IPM concepts is available at: https://ag.umass.edu/landscape/fact-sheets/fundamentals-of-insect-mite-ipm-program. A grape-specific IPM guide, Elements of IPM for Grapes in New York State, can be found at: http://hdl.handle.net/1813/42720

2. **Ask Questions**. At organized grape meetings or informal gatherings of growers ask questions of people who have experience and who are succeeding in cold climate grape production. Many growers have said that they initially learned from a grower "mentor" who was willing to share insights and knowledge. University and extension personnel are also available to help. Everyone had to start at some point in time and most people are willing to share what they have learned with people who are just starting to grow winegrapes.

3. **Observe**. Nothing substitutes for you getting out into your vineyard *at least* once a week during the growing season to specifically observe vine development and to apply what you have learned about key times to manage specific diseases, insects, and other pests. Through observation, you become the 'expert' in your vineyard.

Disease Management

Diseases are a major concern in grape production and the risk of disease increases if they are not managed in a new vineyard and inoculum levels build up over time. This presents a problem if you are relatively new to grape growing and you have not had the opportunity to study and know what disease risks you may have in your vineyard this growing season and the most optimal methods to manage the key diseases. Is there a "skeletal" management program that can be followed while you gain more experience and the knowledge needed to "fine tune" and "customize" your program to fit your specific vineyard conditions?

Nothing can substitute for knowing the biological information about the diseases, the stages the pathogens go through, and the factors that impact the development of the diseases. Also, it is important to know the relative susceptibility of the grape varieties which you are growing to the various diseases and the cultural practices that will impact disease development. All of this knowledge will allow you to make informed decisions on the necessity of using a fungicide, what fungicide to use, and when to use it, -- and, thereby, minimize fungicide use. However, if you need some guidance *now* while you gain more knowledge and experience, the following can be viewed as a possible starting point, i.e., a "skeletal" management program to develop, expand, and modify to your specific conditions.

← New England Small Fruit Management Guide

UVM Fruit Program Relative Disease Ratings for → Cold Hardy Winegrapes

Sample simplified disease management spray schedule for cold-climate grapes grown in Vermont or similar climates.

Terence Bradshaw and Lorraine Berkett, University of Vermont. tbradsha@uvm.edu Updated November, 2022

Timing	Target pest[z]	Chemical family	Example Material[y]	Efficacy rating[x]	FRAC / IRAC code[w]
5-8" shoot growth	PH, BR, DM	mancozeb, captan	Manzate 75, Captan 80 WDG	3-4	N/A
Immediate pre-bloom to early bloom (10-14 days from last spray)[v]	PM, BR BR, DM, AN	DMI **+** mancozeb	Rally Manzate 75	3-4	3 N/A
1st post-bloom (10-14 days from last spray)[v]	PM, BR BR, DM, PH, AN	DMI **+** mancozeb **or** captan	Rally Manzate 75, Captan 80WDG	3-4 2-4	3 N/A
2nd post-bloom 10-14 days from last spray)	BR,DM, PM	strobilurin or SDHI **or** captan **+** sulfur	Flint, Luna Experience Captan 80 WDG, sulfur	3-4 1-4	11, 7 N/A
Additional summer sprays As needed, dependent on weather	Bot DM	SDHI, dicarboximide, AP, KRI Mandipropramid, phos acid, strobilurins	Luna Experience, Rovral, Scala, Elevate Revus, Prophyt	3-4 3-4	7, 2, 9, 17 40,33, 11
or physical injury (hail, etc.)	PM	sulfur, stylet oil	sulfur, JMS stylet oil	3	N/A

Insecticides, as needed determined by scouting, and suggested timing. VT vineyards likely need only one insecticide per year targeted at grape berry moth, although other insect pests may be problematic in certain vineyards, especially on young vines.

Immediate Pre-bloom to early bloom	Phylloxera	NNI, TAD	Assail, Movento	2-3	4A, 23
1st post-bloom, summer	grape berry moth	BT, IGR, Oxadiazine, carbaryl	Dipel, Intrepid, Avaunt, Sevin	2-4	11, 18, 22A, 1A
1st post-bloom, summer	grape leafhopper Japanese beetle	NNI, carbaryl, pyrethroid	Assail, Sevin, Danitol	3-4	4A, 1A, 3A

[z] AN= anthracnose; Bot= botrytis; BR= black rot; DM= downy mildew; PH= phomopsis cane & leaf spot; PM= powdery mildew

[y] Not all materials will be registered for use in all states

[x] Efficacy rating based on 2021 NY & PA Pest Management Guidelines for Grapes and New England Small Fruit Management Guide

[w] Rotate materials after no more than two applications of the same FRAC or IRAC code to deter against development of resistance to pesticides in target populations.

[v] Immediate pre-bloom and 1st post-bloom sprays are the most critical timings for seasonal disease management.

Where trade names or commercial products are used for identification, no discrimination is intended and no endorsement is implied. Always read the label before using any pesticide. The label is the legal document for the product use. Disregard any information in this article if it is in conflict with the label. This is a suggested guide only: all spray decisions should be based on individual pesticide labels in concert with a comprehensive management guide.

Extending the Season: New Frozen Products for a New Market

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Project Description: There is an opportunity for farmers to meet the growing demand for local foods and increase farm profitability by entering a new market for retail sales of frozen value-added products. In particular, farmers could capitalize on opportunities provided by recent investments in regional food processing facilities by freezing produce for retail sales in winter. Like many new marketing opportunities, farmers do not have access to the information they need to determine profitability in the new market: whether the returns from processing and selling retail frozen produce are greater than the costs or producing safe, high-quality food products that meet food safety regulations.

Farmers have indicated that they are interested in the market, but need better information on processing/production costs; food safety/quality assurances; consumers' demand/pricing; and packaging/marketing. Through this project, we combine original research with existing supply-chain information provided by community partners to fill the information gap so farmers can determine whether this could be a profitable market for their operation. Specifically, through this work, we aim to answer business questions: Can local and regional produce be profitably grown and processed (frozen) for off-season retail sales? Do consumers have a higher willingness-to-pay for locally produced and processed frozen foods? And at what costs of producing safe, high-quality, locally grown, and processed frozen foods will not exceed consumers' willingness to pay?

Project Goals and Objectives: The goal of this project is to assess farmer profitability in the Northeast region from selling a new product, retail frozen local foods, by estimating key returns and costs, and profitability.
To do this, we:

1. Estimate consumer demand for locally processed products;
2. Develop non-proprietary standard operating procedures for two safe, high-quality, popular retail frozen fruit and vegetable products, and:
3. Estimate processing/production costs using scale processing pilots and cost data from community partners.

This information fills the knowledge gap that hinders adaptability of retail frozen local sales in the Northeast.

Relevance: We provide additional knowledge regarding local value-added production opportunities to Northeast farmers and other agricultural partners and service providers. This work helps to conduct important market research and product development to that help provide important tools for farmers to guide decision-making in new markets.

Outputs & Extension Materials: https://ag.umass.edu/value-added-food/nifa-planned-extension-initiative/extending-season-new-frozen-products-for-new-market

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Blueberry Weed Management:
Understanding Herbicide Modes of Action and Injury

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Weeds remain a major challenge in highbush blueberry (*Vaccinium corymbosum* L.) 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 blueberry plantations more prone to the development of hard-to-control perennial weeds. Thus, an efficient weed management program in blueberries will rely on use of herbicides. Relying on various herbicides has many advantages, including weed control and cost effectiveness when used appropriately, elimination of blueberry bark or root damages associated with soil cultivation, and reduction of rodent injury by suppressing vegetal ground cover. However, herbicides, when used improperly, can also cause severe crop injury. This presentation will cover some of the basic information about herbicide modes of action and will examine in detail the different type of crop injury associated with herbicides labeled for weed control in blueberry.

Herbicide mode and site of action

The term "mode of action" refers to the sequence of events from absorption into plants to plant death, or, in other words, how an herbicide works to injure or kill the plant. The specific location the herbicide affects is called the site or mechanism of action. To be effective, herbicides must:

1. Adequately contact plants,
2. Be absorbed by plants,
3. Move within the plants to the site of action without being deactivated,
4. Reach toxic levels at the site of action.

Understanding herbicide mode of action is helpful in knowing what groups of weeds are controlled, specifying application techniques, diagnosing herbicide injury problems, and preventing herbicide-resistant weeds. A common method of grouping herbicides is by their modes of action. Although many herbicides are available on the marketplace, several have similar chemical properties and similar way of controlling weeds. Two or more families may have the same mode of action and will be listed under the same group number (Table 1).

Origin of herbicide injury

Herbicides can injure foliage, shoots, flowers, and fruits. If injury is severe enough, it may affect yield, produce poor fruit quality, and occasionally cause plant death. Herbicide symptoms may be visible for a few days to several years depending on the herbicide involved, plant species, stage and rate of growth, environmental and soil conditions, and cultural practices. In addition, herbicides may reduce non-target plant vigor, increase susceptibility to disease, and shorten the life cycle of a plant. Crop injury may be caused by aerial drift (physical or vapor drift) at the time of herbicide application or soon thereafter, soil carryover, soil-adsorbed herbicide becoming airborne as a result of soil disturbance, contaminated tank or herbicide misapplication.

Preventing herbicide injury

Always carefully read the herbicide label and follow directions and recommendations for the best application method. When applying herbicides, avoid the use of highly volatile formulations of herbicides in any area near sensitive crops. Do not spray herbicides when wind is blowing toward sensitive plants or when temperature inversions are likely. It is important to properly select nozzles that will minimize the production of fine droplets and eventually use shielded booms. Reduce the speed at which you spray the herbicide as higher speed may increase the risk of herbicide drift. Consult the label for recommended cleaning agents when cleaning out the spray equipment. Rinsing with just water may not remove the residue and the herbicide may remain tightly adsorbed in the sprayer through several loads. Further loads that contain other herbicides, oils, fertilizers, or basic pH blend may cause the herbicide to desorb, disperse into the spray solution, and damage susceptible crops.

Table 1. Common herbicide mode of action classes and examples for blueberry

Mode of action (effect on plant growth)		Site of action	WSSA group #	Active ingredient	Examples of trade name(s)
Lipid (fatty acid) inhibitor (meristem)		ACCase enzyme	1	-dim -fop	Poast® / Select® Fusilade®
Amino acid biosynthesis inhibitor		ALS enzyme	2	halosulfuron rimsulfuron	Sandea® Matrix® / Solida®
Seedling growth inhibitor	root & shoot	Microtubule	3	oryzalin pendimethalin pronamide	Surflan® Satellite® Hydrocap Kerb®
Plant growth regulator		Auxin mimics	4	clopyralid quinclorac	Stinger® (*NJ/NY 24(c) SLN only*) Quinstar®
Photosynthesis inhibitor	mobile	Photosystem II	5	diuron hexazinone simazine terbacil	Karmex® Velpar® Princep® Sinbar®
	contact	Photosystem I	22	paraquat	Gramoxone®
Amino acid biosynthesis inhibitor		EPSP enzyme	9	glyphosate	Roundup®
N-metabolism disrupter (contact)		GS enzyme	10	glufosinate	Rely®
Pigment inhibitor (bleaching)		PDS enzyme	12	norflurazon	Solicam®
		HPPD enzyme	27	mesotrione	Callisto®
Cell membrane disrupter (contact)		PPO enzyme	14	carfentrazone flumioxazin sulfentrazone	Aim® Chateau® Zeus®
Very-long chain fatty acid inhibitor		VLCFA enzymes	15	*S*-metolachlor	Dual Magnum® (*NJ 24(c) SLN only*)
Cell wall synthesis inhibitor		Plant meristems	29	dichlobenil indaziflam isoxaben	Casoron® Alion® Trellis®
Unknown site of action			0	napropamide	Devrinol®

Examples of some common symptoms of herbicide injury on blueberry

- **Preemergence herbicides**

Norflurazon Carotenoid inhibitor (Solicam® DF)	Leaf **veins turn white or pinkish white**. Current-season shoots may turn white (bleaching) Symptoms usually appear first on lower branches. Norflurazon is persistent in the soil, so excessive rates may not result in symptoms until late in the season or the following year.	
Simazine Photosystem II inhibitor (Princep® 4L)	Symptoms are similar to those of iron chlorosis with **interveinal yellowing, browning and necrosis along leaf edges**. Bushes with mild to moderate symptoms survive but grow poorly for several years.	
Diuron Photosystem II inhibitor (Karmex® DF)	The first apparent symptom is an i**nterveinal pale green/yellow color**. Brown areas will later appear between the main veins in the middle of leaves and will extend to the leaf margins. Plants can show some stunting but will usually recover.	
Terbacil Photosystem II inhibitor (Sinbar® WDG)	Injury symptoms appear as **irregular chlorotic patches on leaves that will later turn brown** and die. Leaves curl and eventually drop from bushes. Severely affected bushes may drop all leaves and die by the following spring.	
Pendimethalin Seedling growth inhibitor (Satellite® Hydrocap)	Injury symptoms appear in the form of abnormal shoot growth with reduced internodal growth as well as **leaf stunting, crinkling, chlorosis and marginal necrosis**. Severe fruit damages appear as equatorial russeting, splitting, and abnormal development of the fruit calyx.	
Flumioxazin Cell membrane disrupter (Chateau® SW)	Symptoms of soil-adsorbed herbicide becoming airborne appear as **reddish spots that will turn brown and necrotic** later in the season. This is usually associated with leaf crinkling and young leaves taking on a red coloration.	

- **<u>Postemergence herbicides</u>**

Glyphosate Amino acid biosynthesis inhibitor (Roundup®)	Because glyphosate can be absorbed and move throughout the plant, severe injury or plant death may occur the following year. Branches produce **<u>stunted growth with small, narrow, chlorotic leaves</u>**. Symptoms may persist for 1 to 3 years.	
Paraquat Photosystem I inhibitor (Gramoxone®)	Paraquat injury will stay confined to treated parts. **<u>Brown necrotic spots</u>** develop on sprayed leaves that may drop depending on the severity of the injury. Green bark on young canes can show reddish-brown lesions, causing stunted growth or death if the bark surface is injured.	
Glufosinate Nitrogen metabolism disrupter (Rely® 280)	Injury symptoms appear as leaf of green bark burning within several hours following exposure. **<u>Leaves crinkling and reddening</u>** followed by complete necrosis are frequent symptoms as well as **<u>bark cracking</u>** on young green stem exposed to glufosinate.	

Information and pictures from "**A Pocket Guide to IPM Scouting in Highbush Blueberries**" by A. Schilder, R. Isaacs, E. Hanson, B. Cline and M. Longstroth, available at <u>https://www.canr.msu.edu/resources/a-mobile-guide-to-ipm-scouting-in-highbush-blueberries</u>

Strategies for growing organic berries at Adam's Berry Farm

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Adam started his diversified berry farm in 2001 in Burlington, VT where he worked to establish the farm and build market connections. In 2012 Adam and his partner Jessica purchased land in Charlotte, VT with the help of the Vermont Land Trust and the Farmland Access Program. We then embarked on the task of relocating the farm, building new infrastructure and expanding our plantings. Today we operate 57 acres where we grow high-quality certified organic strawberries (June and ever-bearing), summer and fall raspberries and blueberries. Our fruits are sold at numerous markets and restaurants, CSAs and breweries throughout Vermont. All of the berries we grow at the farm are certified organic by VOF. We are variety and flavor focused. Currently we grow 3 acres June strawberries, 2 acres day neutral strawberries, 1 acre of high tunnel raspberries, approximately a 1 acre mix of field summer and fall raspberries, 13+ acres of blueberries (23 varieties) and a small and highly neglected pear orchard. Being a berry farm, we have limited crop offerings but a diverse model of sales and distribution outlets to create stability. We have a strong wholesale presence, attend farmers markets, operate a small farmstand, run a PYO and produce value added products focusing on frozen berries, popsicles and sorbet.

During the session we will cover a variety of topics that have aided in our success in the last 21 years of growing blueberries. We will address organic production methods, variety selection, harvest and post handling considerations and balancing wholesale and pick your own markets. In addition we will talk about:

-Scaling up our production to meet market and business needs. We had been stuck in a small farm size with high business, labor and infrastructure needs. We will discuss how we grew the farm to match the demands of the farm while stabilizing labor needs.

-High tunnel production of blueberries for the local market. Pro and cons.

-Modern blueberry varieties for efficiency and reduced labor, shelf life. Choosing blueberry varieties for specific sales outlets.

-Addressing the harvest intensity of blueberries. How to handle labor needs and demands. How and when to use a harvester for our markets. When to open and when to close PYO.

-The introduction of a sorting line and packing equipment for quality and efficiency and food safety

-Looking at pruning as an annual investment. Pruning tips for worker/crew, plant and pick your own happiness. Factoring in harvest speed, fruit quality, size, disease and more. Electric/ battery

pruners for long term success and health. Knowing what each variety needs when it comes to pruning – each variety has its own specific pruning needs.

-Market outlets for our success. Wholesale, farmstand, PYO, farmers markets. Finding outlets for seconds fruit. Breweries, cideries, juice, jam companies.

-Top pest and diseases that we manage.

Database and software management tools to help your farm grow

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Farm data can be used as a powerful tool, but collected or stored ineffectively, that same data can lead to frustration and poor decision making. In ten years of farming, we have tried dozens of different record keeping strategies, database formats, and customer management software, from pen and paper to fully automated online CSA management programs. Through trial and error, we've found a mix of basic and advanced technologies that fit our farming needs and crew preferences. There are four major areas of our business that we have focused on for leveling up (or not) our management tools: record keeping[1], budgeting, crop planning and CSA management/online store sales. This presentation will cover technologies that we have tried in each category and will cover why we currently use a range of basic (record keeping) to advanced (CSA management) technologies.

We have learned that above all, creating effective data comes from using methods that are easy to use and produce the service or information that we actually need.

Record Keeping

Databases need accurate data in order to give us the information that we need to make smart decisions for our businesses. The only way that I've found to create good data is to have record keeping systems that are easy to understand and execute. That means data collection occurs in places where the action happens, with easily accessible and necessary tools. The actual method of data collection depends on you and your crew's personalities and tastes. For example, our crew would rather have a clipboard, paper[2] and pen hanging on the door of the chicken coop to record eggs laid rather than log the numbers on their phone. I personally would rather log it in my phone (I would use a Form on Airtable or Google that would automatically input data for me so that I didn't need to transcribe it later from paper), but when we have tried to implement electronic data collection we have *always* had gaps in our data. Therefore, I ask the people who are most likely to do the data collection how they would like to do it and have them try a few methods for a few days until they have settled on something that works for them. This may result in more data entry in the off-season, but I would prefer that to inaccurate data or frustrated co-workers!

Over the years we have also learned to only keep data that is relevant and necessary. We start with our Organic record keeping requirements, make sure we are accurately recording and

[1] We use QuickBooks Online for most of our financial record keeping and wholesale invoicing. Now that we use GrownBy for CSA management, our CSA and online payments are processed through Stripe and are imported to QBO. We chose to transition from the desktop to online version of QuickBooks so that we could create or edit invoices when away from our computer, and because it allowed our bookkeeper to access our data more easily. Yes, there are limitations of the online version especially for reporting and paying 943 taxes, but the benefits of mobile use outweighed the limitations in our systems.

[2] Because we do so much record keeping on paper, I like to print collection sheets on Write In The Rain paper.

keeping that data, then we may or may not look for additional data if we have determined that it is necessary to help us make an important decision. For example, we have harvest yields data on all of our crops on daily harvest records. These records are on paper, and they sit in a folder on my shelf for the required 4 years of Organic record keeping and then are recycled. That means that I have no idea how many carrots we harvested last year, and I'm ok with that. If we really needed to add up our carrot yields, we could, but so far I haven't found a compelling reason to know total yields besides a gut feeling of whether or not we grew enough of each crop. There have been and will be cases in which we are interested in total yields. In this case we talk to the crew about the reason for additional record keeping or data entry (maybe we are participating in a cost of production study on tomatoes), and we take more meticulous records on those specific metrics.

Budgeting

As our business ages and our costs stabilize (relatively, I know that costs are rising and unpredictable right now), I have found it to be more and more important that we have a live budget/cost flow document that can help fuel our decision making throughout the season. Budgeting could be a whole workshop on its own, but I have found Excel to be the best tool in creating a powerful budget. We worked with a bookkeeper who helped design a worksheet that allows us to input costs by month (informed by QuickBooks reports from the previous season), project employee salaries, plan for projects, and estimate income. My favorite feature is that I can plug in the dollar amount in our bank account at January 1, and the worksheet predicts my bank account amount at the beginning of each month. This is the best tool I've found at being able to glance at my bank account, then the budget and notice if there is a wild discrepancy without needing to keep up to date with entering income and expenses. (I don't do much bookkeeping from June – September, so this tool helps me know if I should worry or not.) I've tried using QuickBooks and YNAB for budgeting, but I find that neither work for forecasting a CSA (large income early in the year) type business.

Crop Planning

We grow year-round on small acreage (about 2 acres in production) for a 150+ member CSA and several wholesale outlets. To be successful we've found the need for a tight crop rotation with narrow windows between planting successions, an accurate plan for bed space needed, and seasonally precise planting dates. Our original crop plan utilized excel, following templates from *Crop Planning for Organic Vegetable Growers* by Frederic Theriault and Daniel Brisebois. This method worked moderately well, but we experienced numerous issues due to accidental formula errors, copying and pasting mistakes, and general eyeball fatigue from looking at so many worksheet cells. We looked into non-farming specific database options, but found that most required we work with a representative to design a database, and a significant time and financial investment. As beginning farmers, the benefit did not justify the cost. We tried Tend, a farm specific crop planning and record keeping software, but after using it for a trial period we learned that it did not fit our farming personalities. Namely, we found that our field and wash/pack crews did not like to rely on digital technology in the heat of the farming season. Rather, we find that we like to use technology for off-season planning and prefer to print off informational or record

keeping sheets for use during the Summer. Therefore, our level up in crop planning has gone from paper to Excel, and is currently managed by a home-made Airtable database.

Airtable is a prettier, more beefed-up version of Excel. Imagine pages and pages of Excel data that is manipulated by formulas into easy to read, easy to edit, and difficult to screw up pages of information. The program is housed online and is free unless you want to use some of the more advanced (very advanced, I only know two farmers who need them) options, or if you are like me and you want pretty color coding to go along with your databases. It's low cost, free or $24 per month, and relatively easy to learn. I am not a coder by any means but had a clear picture of what I wanted my crop plan database to look like and, assuming that it was possible with this program, I Googled my way to creating it. Now that it's finished, we can edit the data in the off season, without concern of ruining a formula, and print sets of seed orders, greenhouse planting, field planting, and amendment information for the season. We then enter actual information from paper back into Airtable and save it for easy reference for future planning or Organic inspections. My Airtable crop plan is available online for farmers to copy as a template and fill in with your own data. https://www.patreon.com/posts/our-crop-plan-33426179

CSA Management

We have invested the most time and money into advancing technologies for our CSA database. Until 2020 I had used an online form to collect signup information, input those orders into QuickBooks for billing purposes, and further organized the information in Excel for membership coordination. This meant hours of data input in January – April, but I was happy to do it because we didn't have much else going on that time of year. In 2018 I upgraded to an Airtable database, which integrated my signup form, allowed me to see historical data for each customer, and worked better than Excel for sorting customers by pickup location, add-on options, and season. These systems worked until the birth of our first child, and the beginning of the pandemic. Pre-baby I had been the primary CSA manager, and was able to keep up with signups, invoicing, and day to day management. After he was born, I couldn't keep up with the expanded membership while also acting as primary caregiver to our son. I was making mistakes, hopelessly behind on invoicing, and I worried that our overall CSA product was suffering because of it.

We didn't have the time or wherewithal to trial CSA management systems as we navigated the beginning of the pandemic, but we did respond to consumer demand and added an online store through Barn2Door. It served our purposes but took so long to load on our rural internet that we looked for a new option for our 2021 season. In 2021 we started using GrownBy, an online platform that allows for an online store plus CSA signups and management. I was hesitant to go all in, so tried it as our online store option alongside my original Airtable CSA database. At the time the platform was new, but had all the components and potential that I had been looking for. Plus, it is designed and managed by CSA farmers, so I had confidence that my feedback would inform future updates. After GrownBy released updates earlier this year, we moved our CSA signups to GrownBy for the 2022 season, and I have been grateful for it ever since. There are several CSA management software options to compare, each with benefits and drawbacks. When I was shopping around, I looked into each of them, and GrownBy's format best matched our

CSA style, and their pricing structure made sense to me[3]. I worried that going digital would be hard for our members, but after the pandemic, most people are used to ordering online, and they have seen how much more streamlined our systems have become because of it.
I won't promote one platform over another because each CSA is so unique and may require services provided by a different platform. Instead, I think the important point is that we decided to take the time and money to invest in this type of database because it solved a persistent problem: stress and mistakes due to our existing CSA management systems.

In closing, I'd like to reiterate that our spectrum of database technologies stems from a desire to find the best technologies for our farm, but an understanding that sometimes the newest and flashiest technology isn't right for my team. I have spent hours of time and hundreds of dollars exploring online budgeting programs, or crop planning programs, only to see my co-workers' eyes glaze over as I propose that they enter data on cell phones or tablets. The best solution for me is a solution that works for the people I work with, so my criteria for leveling up are:

1. does it solve a real problem?
2. ok, but *does* it solve a *real* problem?
3. will we use it?

I've found over time that my first reaction to "does it solve a real problem" is usually an emphatic, "yes!", but when looked at deeper, or discussed with my team, the answer more often becomes, "no", or "maybe?". Once the answers are emphatic "yes", "yes" and "yes", that's when I know it's time to proceed.

[3] GrownBy charges a 2% Co-op fee per purchase plus the usual 2.9% credit card processing fee. Customers pay an additional 30 cents per credit card transaction. No fees for offline (cash or check) transactions. The 2% fee fuels the Co-op, which is cool because the business is a farmer owned co-op! To cover these additional costs, I increased all of our items by 5% and told our CSA members that we were making this change because it would provide a better experience for them, and would provide us with more time to spend with our new baby. No one complained.

The Farm and Ranch Stress Assistance Network (Cultivemos) and How you Can Tap into Resources

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Cultivemos, the network for farmer well-being
(formerly Farm and Ranch Stress Assistance Network - Northeast)

In the 2018 Farm Bill, USDA's National Institute of Food and Agriculture (NIFA) awarded $28.7 million to four regional entities to develop FRSAN Networks to help ensure that agricultural communities have increased options for access to supportive services where they live and work. The 13-states of FRSAN-Northeast (FRSAN-NE) are collectively called Cultivemos and received $7.1 million over three years.

CULTIVEMOS HIGHLIGHTS

- **NETWORK MEMBERS** from 91 organizations
- **NEW RESOURCES**. Cultivemos' cohorts produced and distributed 32 new farm stress related resources in 2021-22. A few examples:
    - Cultivating Resilience Podcast
    - Directory of many, diverse resources on Farm Aid's website
- **COHORT MODEL**. Cultivemos uses a cohort model of network building. Members work together in small cohorts to share and create new resources in their area of interest and expertise. Cultivemos re-grants funds to these cohorts so that agricultural professionals can serve farmers' and farmworkers' emergent needs.
- **REFERRALS.** Northeast farmers were given the following referrals through the FarmAid Hotline:
    - 337 Referrals to organizations within the FRSAN-NE region
    - 114 Referrals to USDA programs
    - 21 Referrals to FSA programs
    - 18 Referrals to University Extensions
- **TRAININGS.**
    - 24 Trainings held in 2021-22
    - 500 Participants trained
- **PROJECT SPENDING.** Allocated funds as of Sept 14, 2022
    - $550,000 to grassroots organizations
    - $220,000 to farmers and farmworkers
    - $675,000 to ag service providers
    - $117,000 to language justice services

This work is supported by the USDA National Institute of Food and Agriculture, Farm and Ranch Stress Assistance Network (FRSAN) project 2019-70028-30464 and 2020-70028-32729.

State Department of Agriculture Farm and Ranch Stress Assistance Networks

In most states in New England, there is a state effort for Farm and Ranch Stress Assistance. Contacts in each state can share more, and the states each have websites with state-specific information about supportive programs and offerings.

STATE	LEAD(S)	EMAIL	AGENCY/ORG
Regional	Gaby Pereira	gaby@nefoclandtrust@org	Northeast Farmers of Color Land Trust NGFOC
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WV	Lisa Lagana	lisa.lagana@mail.wvu.edu	West Virginia University Extension Service
WV	Leslie Boggess	lboggess@wvda.us	West Virginia Department of Ag
WV	Michelle Parsons	michelleparsons@wvda.us	West Virginia Department of Ag

Farm Aid Hotline

Is your stress level on the rise?

Call and talk with someone who understands farming.
This is a free service.

Monday through Friday from 9 a.m. to 10 p.m. EST

1.800.FARM.AID (1.800.327.6243)
will connect you with a person who can help.

Other Maine Resources

Mano en Mano supports Maine immigrant and farmworker communities through access, advocacy, and education.

manomaine.org
info@manomaine.org | 207.581.3487

Maine Agricultural Mediation Program provides help when farmers are experiencing conflict. In mediation, farmers meet with a neutral party to work through conflict with their lenders, employees, or neighbors.

extension.umaine.edu/agriculture/agricultural-mediation
maineagmediation@maine.edu | 207.546.3006

Maine Mobile Health Program links agricultural workers to care and services in order to reduce health disparities and inequities of access for this workforce.

mainemobile.org/our-work
mmhp@mainemobile.org | 207.622.9252

988 Hotline

The **National Suicide Prevention Lifeline (dial) 988** provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, seven days a week, across the United States. Calls made in Maine will be routed based on their area code and connected to a trained crisis specialist at the Maine Crisis Line. This line is not tied to law enforcement agencies. You do not have to be suicidal to call.

THE UNIVERSITY OF MAINE
Cooperative Extension

Farm Wellness

Healthy farms need healthy farmers. Our minds and bodies need maintenance just like our farm tractors, chainsaws and boats. Stress is felt in many ways. Don't wait for injury or burnout to seek out helpful resources.

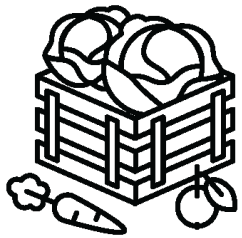
maine Department of Agriculture Conservation & Forestry
AGRICULTURE

Legal Needs

FLAG/Farmers' Legal Action Group is dedicated to helping farmers understand their rights. 1.877.860.4349.

Legal Food Hub matches farmers with the legal help they need, pro bono (free) In Maine, call: 1.844.529.4769.

Pine Tree Legal provides free legal aid in Maine through county offices. Farmworker Unit: 1.800.879.7463.



Resilience Tips

Stay connected
Practice awareness
Take care of yourself
Plan and set goals
Cultivate wellness

Did you know?

Connection is considered an antidote to stress.

Reach out to a family member, a friend or your local agricultural service provider today.

Connect online:

UMaine Extension website focused on agricultural wellness and resilience.

@mainefarmwellness

Connect offline:

Listen to your favorite music

Sit with a pet

Read a poem, a book, or article about wellness

Take a walk or stretch

Practice "box breathing"

Inhale while counting to four

Hold your breath and count to four

Hold your breath and count to four

Exhale while counting to four

Poster #2022-01. Effect of Ultra-fine ozone bubbles in inactivating *Listeria monocytogenes* and *Salmonella* Enteritidis on Romaine lettuce

Abhinav Upadhyay
Presenting Author

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Indu Upadhyaya	Food Safety Assistant Extension Educator, University of Connecticut, Storrs, CT
Abhinav Upadhyay	Assistant Professor, University of Connecticut, Storrs, CT

Abstract: The widespread distribution of *Salmonella enteritidis* and *Listeria monocytogenes* in agricultural environments such as manure, soil and irrigation water results in frequent contamination of fresh produce. Water used for produce washing can act as a source of contamination. Since this could lead to human infections, controlling *Salmonella* and *L. monocytogenes* in wash water and surface of fresh produce is critical for food safety. Currently used commercial disinfectants are not completely effective in killing the aforementioned pathogens on the surface of produce, especially in the presence of organic load. Therefore, there is a need for developing novel strategies that could be employed to control foodborne pathogens in wash water and on surface of fresh produce. The overall goal of this project was to develop novel washing treatments using ultra-fine bubble technology in combination with ozone to reduce the survival of *Salmonella* and *L. monocytogenes* on fresh produce (Romaine lettuce) and in wash water. Ultra-fine ozone (UFO) bubbles were produced using an ozone generator-nanobubble generator dual system. The UFO bubbles in water were characterized for size and number. Bubble characterization results indicated that the bubble number in water was approximately 10^8/ml with size ranging from 90-150 nm. The dissolved ozone concentration in UFO bubble water was ~ 5 ppm at 25°C. Washing of Romaine lettuce with ultra-fine ozone bubble water significantly reduced *L. monocytogenes* load by ~ 1.5 log CFU/sample, as early as 1 min of treatment time ($P<0.05$). No significant increase in efficacy against *L. monocytogenes* on lettuce was observed by increasing the wash time to 5 min ($P>0.05$). The wash treatment did not affect the color parameters (L, a, b values) of lettuce ($P>0.05$). No *L. monocytogenes* was detected in wash water (> 5 log CFU/ml reduction). Experiments investigating the efficacy of UFO bubble water in reducing the survival of *S. enteritidis* on Romaine lettuce are currently underway.

Poster #2022-02. Survey for Entomopathogenic Nematode Populations in Apple Orchards of Western Massachusetts

Matthew Bley
Presenting Author

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Mateo Rull-Garza	Research associate, University of Massachusetts, Amherst MA
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Abstract: Plum curculio (*Conotrachelus nenuphar*) (PC) is an economically devastating pest to pome and stone fruit production. Recommended pest-control methods (such as insecticide application and pheromone-based trapping) and cultural controls work to great effect managing this pest but can impose an important financial and logistical burden on farmers. As an alternative, some entomopathogenic nematode (EPN) species are effective biological control agents for PC, attacking the developing larvae as it pupates underground. By using established aggregation techniques, designated trap trees can focus PC activity and larvae in a specific area for the use of insecticide and EPNs to curb the current and future population. By sampling the soil of grafted trees that attract higher traffic of PCs, we sought to monitor the presence of native EPNs that may target PCs in Massachusetts. Soil from unmanaged trees, subject to organic practices, were also surveyed to determine whether practices that allow for more insect activity could influence native presence of entomopathogenic predators. Specifically, we hypothesized that natural soil biota, including native EPNs, can be detected from soil traps inoculated with *Galleria mellonella L.* (wax moth) larvae, a species susceptible to EPN attack. To test our hypothesis, soil samples were collected from managed apple trees at the UMass Cold Spring Orchard (Belchertown, MA) and unmanaged trees from an organic farm (Amherst, MA). *Steinernema riobrave* and water were used as positive and negative controls, respectively. Then, we monitored the mortality of wax moth larvae introduced into each soil sample. Significantly greater levels of wax moth larval mortality were recorded in soil from unmanaged trees compared to managed orchards. Our findings are expected to inform growers on the presence of natural PC enemies relative to the management practices and cultural controls implemented in their orchard.

Poster #2022-03. The influence of ground cover on Spotted-Wing Drosophila (*Drosophila suzukii)* infestation in New Hampshire highbush blueberry

Catherine Coverdale
Presenting Author

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Abstract: Spotted wing drosophila (*Drosophila suzukii)* has become an increasingly important pest to New Hampshire to small fruit growers in the past decade. Female spotted wing drosophila (SWD) have a serrated ovipositor which allows them to lay eggs in ripe and ripening fruits, setting them apart from native fruit flies which can only lay eggs in rotten fruits. While broad-spectrum insecticides are recommended as a conventional control method, cultural controls offer an alternative that could reduce infestation while staving off the potential for pesticide resistance. Ground cover has been reported to provide efficacy in reducing infestation in some scenarios, but no regionally relevant data exists. The objective of this research was to determine if there was a notable reduction in infestation between treatments of either black or white weed mat and how ground covers influenced temperature, relative humidity, and light to make the crop environment less favorable to the pest. We hypothesized that white and black woven polyethylene weed mat treatments would have lower levels of infestation compared to grower standard wood chips. Blueberries were harvested from plots twice weekly for three consecutive weeks, and the salt float method was used to determine larvae per gram of fruit as a measure of infestation. Our findings will provide growers with research-based evidence for implementing low or no-spray management practices.

Poster #2022-04. Reduced risk and chitosan treatments suppress apple scab caused by *Venturia inaequalis* on leaves and fruit

Liza DeGenring
Presenting Author

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Anissa Poleatewich	Assistant Professor, University of New Hampshire, Durham, NH

Abstract: Apple scab caused by the fungus *Venturia inaequalis* is the most destructive disease of apples in the Northeast U.S. Concerns over residues and the development of fungicide resistance have prompted interest in developing alternative tools, such as biopesticides and natural products. Applications of the natural product chitosan have been shown to induce plant defenses and reduce postharvest plant disease severity in several crops. We hypothesize that an application of chitosan and biopesticides could have a synergistic effect on reducing disease. The objectives of this research were to 1) examine the efficacy of foliar applications of chitosan to reduce apple scab and 2) investigate the potential to improve biopesticide efficacy through co-application with chitosan. Research orchard trials were conducted to compare the effects of five treatments on reducing *V. inaequalis* on apples: water, grower standard, chitosan, reduced risk, and a reduced risk plus chitosan. Apple scab incidence and severity data were collected on leaves and fruit. We observed that the reduced risk treatments could reduce apple scab as effectively as the grower standard. Plants treated with chitosan had less apple scab severity when compared to the grower standard. Our results suggest that a reduced risk treatment is as effective as the grower standard treatment and that chitosan has the potential to be used as an alternative tool for integrated disease management of *V. inaequalis*.

Poster #2022-05. Investigating food safety process parameters for Lacto-fermented sauerkraut

Julia Fukuba
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Abstract: The rise in consumer interest for lacto-fermented foods has peaked the business opportunity for lacto-fermented foods, yet established critical limits that validate process control is limited. The aim of this project is to investigate the fermentation rate under different process conditions including fermentation vessel and change in formulation (salt concentration) over time. Lab-scale sauerkraut was prepared with 4mm-shredded pieces of cabbage and mixed with sea salt for 15 minutes, filled with fermentation vessels with saltwater weight bags applied on top of cabbage below brine level and monitored over time (up to fourteen days). Experiments included change in sea salt concentration (0. 1.6, 2.4, 3.2, and 6.4%) and change in fermentation vessel (32, 16, 8-ounce glass jars). Physical characteristics (pH and water activity) were measured with statistical analysis using ANOVA and t-test/Kruskal-Wallis test to investigate the kinetic change over time. Results report that certain process parameters can change the fermentation process in some conditions. 1.6, 2.4, and 3.2% salt sauerkraut samples significantly lowered the pH (4.55 ± 0.12 by Day 5, 4.60 ± 0.11 and 4.45 ± 0.16 respectively) compare to the other concentrations. Fermentation vessel size reported that smaller vessels had a statistically higher pH level by day 3 (pH 4.65 ± 0.02) compared to large (4.11 ± 0.03) and medium vessels (4.00 ± 0.05). Lactic acid bacteria counts significantly increased for 1.6 and 2.4 % salt sauerkraut after 36 hours of fermentation. Water activity values changed over time depending on the salt concentration of sauerkraut samples; water activity readings for all salt concentration samples increase for the first two days, then significantly decrease after day 5. Identifying the rate at which the pH is reduced below 4.6 in lacto-fermented foods such as sauerkraut, can help provide process controls that provide technical support for processors.

Poster #2022-06. Evaluating the risks associated with utilization of modified washing machines in the processing of leafy greens

Pragathi Kamarasu
Presenting Author

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Abstract: About 46% of U.S. foodborne illness incidents are attributed to produce, of which leafy greens are responsible for most. When considering the farm-to-fork chain, microbial contamination of fresh produce can occur at multiple stages. More specifically, due to improper post-harvest handling of produce, not following GAP and by inefficient cleaning or sanitizing of the food contact surfaces. The CDC has reported two recent listeriosis outbreaks in 2021 in leafy greens in Dole Packaged Salads and Fresh Express Packaged Salads. One such practice where small and medium-sized growers commonly retrofit washing machines to dry triple-washed leaves, utilizing their spin cycle, effectively turning them into large salad spinners. However, the potential for this practice to cause microbial contamination and the degree to which it can pose a risk to cause foodborne illnesses has not been explored. This project aims to investigate the risk of cross-contamination associated with the practice of drying leafy greens with retrofitted washing machines to help inform best practices to mitigate risks. *Listeria innocua* at 102-109 CFU/ml was inoculated and dried onto spinach prior to washing, after which leaves were dried in a retrofitted washing machine. After drying, three contact surface layers of the machine (loading basket, internal chamber, water collection chamber) were sampled using sterile microbial swabs and ATP swabs to enumerate the relative levels of the bacterial transfer, with 3 swabs per region. There was a nearly complete microbial recovery of 98% and 99% from the contact points after 103 and 106 of initial *Listeria innocua* inoculated respectively. The highest level of recovery was consistently measured in the bottom water-collecting contact points, suggesting the highest risk of bacterial deposition may occur in this region. *L. innocua* from contaminated loading baskets were transferred to non-inoculated spinach during the spin-drying process with a microbial recovery of 101-102 CFU/area, a concern for *Listeria* as it is psychotropic and has potential to grow in the refrigeration conditions. For a lower inoculation load of 103 CFU/ml the ATP measured from the contact points were 200-40K RLU and 100-7K RLU when measured with Kikkoman and Hygiena machines respectively. The results from evaluating different methods of application of cleaning agents have shown minimal reduction of the ATP recovered and validates the need for establishing cleaning and sanitation guidelines to improve the safety of processing leafy greens in this manner. Hence, additional analysis is required to determine the most efficient cleaning and sanitation method.

Poster #2022-07. Evaluation of Entomopathogenic Nematodes against Plum Curculio: Effects of Nematode Species, Application Rates, and Persistence

Jaelyn Kassoy
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Jaime Piñero	Extension Professor, University of Massachusetts, Amherst MA
Tracy Leskey	Research Entomologist, USDA ARS, Kearneysville, GA
David Shapiro-Ilan	Research Entomologist, USDA ARS, Byron, GA

Abstract: *Conotrachelus nenuphar* (commonly known as plum curculio = PC) is an important pest weevil for apple growers throughout the northeast. Although there are insecticides on the market to combat PCs, growers must make sure to spray at the right time, with a very short window of opportunity. Entomopathogenic nematodes (EPNs) act as a form of biological control, working to control PC larvae in the soil. We conducted two studies that aimed at (1) determining which species of nematodes, and in what concentration are most effective at killing PCs in the soil, and (2) evaluating the persistence of EPNs in the soil from applications the preceding year. Our results suggest that *Steinernema riobrave* either alone or in combination with *S. carpocapsae* was effective at killing PC larvae in the soil. When applied alone at low and high rates, *S. riobrave* also performed well. Results of our second study suggest that some EPNs may have survived the winter as determined by mortality of wax moth larvae, *Galleria mellonella,* which were used as a sentinel host. We conclude that EPNs have potential for pest reduction. EPNs could also be another tool for organic farmers in their fight against pests.

Poster #2022-08. Monitoring wasp parasitoids of the Brown Marmorated Stink Bug (*H. halys*) in Massachusetts

Mateo Rull-Garza
Presenting Author

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C. Jaime Piñero	Extension Professor, UMass Amherst, Amherst, MA

Abstract: With an ability to infest a wide variety of farm produce, and with little natural enemies to combat, the invasive Brown Marmorated Stink Bug (BMSB) constitutes a substantial threat to United States agriculture. Biological control of BMSB by parasitoid species may play an important role in suppressing BMSB populations. Much of what we know about parasitoids of BMSB comes from studies that use sentinel eggs. In this study, we sought to (1) identify the complex of native species of egg parasitoids of BMSB, and (2) to determine whether the samurai wasp (*Trissolcus japonicus*) is present in Massachusetts. The samurai wasp is native to northeast Asia, where BMSB comes from. Samurai wasp females lay their eggs inside the BMSB eggs, killing developing nymphs and hatching as adult wasps. This wasp species is now found in at least 12 U.S. states including Pennsylvania, New York, and New Jersey. We do not know if the Samurai wasp has arrived in Massachusetts. To that end, we selected nine fruit orchards throughout the state. On the woody perimeter of each orchard, we deployed an average of 11 (± 2.63) BMSB egg masses that were previously killed by freezing for 48 hours at -80 degrees Celsius. These sentinel egg masses were then retrieved 72 hours after deployment. The egg masses were incubated and checked at least once per week for wasp parasitoid emergence for 5 weeks. On average, in May and June of 2022, little predation was observed (1.5% and 3.5%, respectively) and no parasitism was observed. In July 2022, an average of 9.6% of eggs were predated, and 2.5% of all eggs were parasitized. In total, 84 wasp parasitoids (*Trissolcus euchistus, Telenomus podisi, Anastatus sp;* in order of prevalence) were retrieved in July from five farms across the state. No Samurai wasps were detected in our surveys. Our results may provide commercial farm producers with another Integrated Pest Management tool involving biological controls to naturally counteract the rise of BMSB populations in the region.

Poster #2022-09. Assessment Of Disease Threats And Biofungicide Efficacy In Wood Substrates

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Brian Jackson	Professor, North Carolina University, Raleigh, NC
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Abstract: In greenhouse production, plants are not typically grown in soil, but in soilless growth substrates. For decades, peat moss has been the primary substrate for container grown ornamentals and some vegetable crops. Substrate manufacturers have identified wood byproducts to be some of the most promising alternative sources of raw materials for use in substrate formulations. Unfortunately, a change in substrate can be very disruptive to a grower's production system affecting everything from water to pest control. Our objective was to evaluate how wood components (1) affect severity of soilborne disease and (2) affect biopesticide efficacy. Wood components are manufactured in multiple ways with the three most common being hammer milled, twin-disc refined, and single or twin-screw extruded. In this study we evaluated the three differently processed WFs for natural suppression and biopesticide efficacy against damping-off disease on radish and crown and root rot on chrysanthemum caused by *Rhizoctonia solani*. Our findings provide evidence that the inclusion of wood components, regardless of blend ratio or type, does not impact severity of damping-off disease of radish and may lessen the effect of crown and root rot on chrysanthemum. We also found that blending of wood components with peat did not affect efficacy of the biofungicide Rootshield WP. There is still very little known about the effects of wood component type and inclusion rate on soilborne diseases and disease management. Additional research is needed to determine if the trends we observed hold true for other plant species or other pathogens.