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What's New in Sweet Corn

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Sweet corn hybrids have advanced considerably since the days of Golden Bantam, with modern genetics now designed to meet diverse needs for flavor, yield, and crop resilience. Today's sweet corn falls into four primary genetic categories: **Normal Sugary (SU)**, which delivers a classic corn taste but loses sweetness quickly after harvest; **Sugary Enhanced (SE)**, with a creamier texture and longer-lasting sweetness; **Supersweets (SH2)**, known for double or even triple the sweetness of traditional varieties; and **Synergistic (SY)** hybrids, which combine traits to offer a balanced profile of taste and shelf life. Within these categories, Supersweets and Sugary Enhanced hybrids have seen a rise in additional traits, such as improved shelf life, insect resistance, and overall crop consistency under challenging conditions.

New sweet corn varieties undergo a rigorous development process, often with years of trials prior to market introduction. Each breeding pipeline follows a structured approach, from planting to harvest, with careful data collection on key traits like kernel quality, ear size, disease resistance, and taste. Commercial variety benchmarks are used as checks, allowing breeders to evaluate the new varieties in comparison to standards in the industry. Varieties that demonstrate high performance in trials are eventually advanced to commercial farms, where farmers can access crops tested under realistic growing conditions.

Recent highlights in sweet corn genetics emphasize improvements in agronomic yield, with breeding advancements reducing crop losses due to pest and environmental pressures. By exploring correlations between seeding rates and yield, breeders are also pushing productivity to new levels. Notable varieties in our program include **Bolt**, recognized for early vigor and yield potential; **Solstice**, with impressive sweetness and quality; **Superb**, known for high quality kernels and top-rated vigor; **Stamina**, for its durability under stress; and **Redemption**, high yielding and dependable.

Climate Smart Fertility Management

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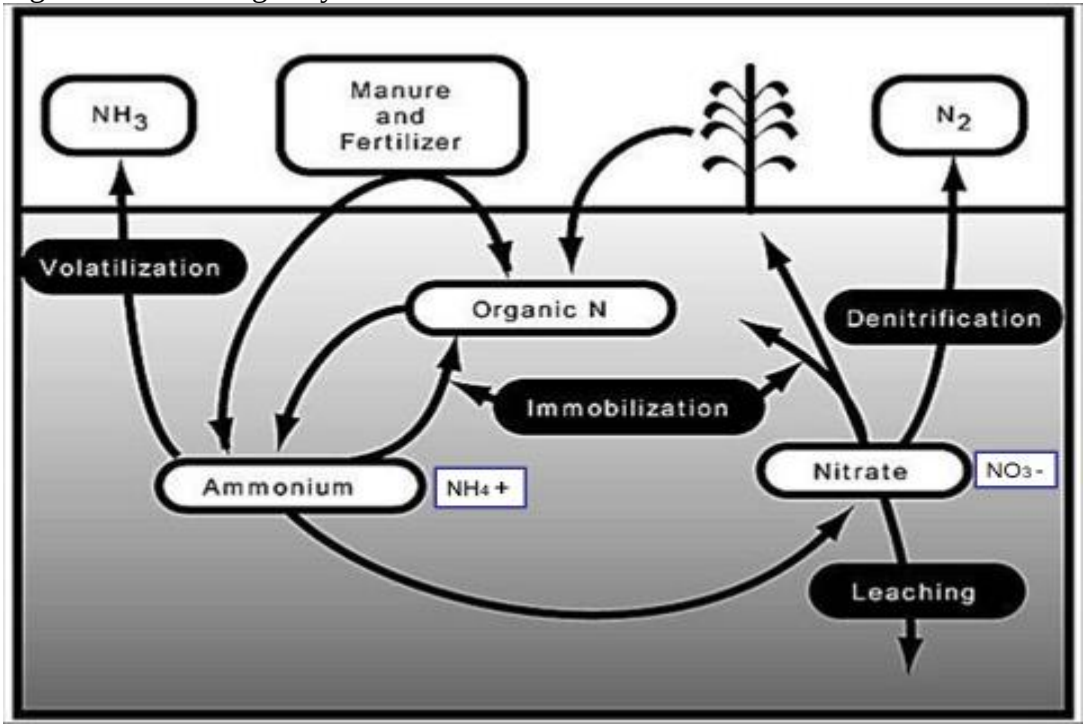
Increasingly erratic weather has become a common problem in all parts of the country. In the Northeast, there is a definite trend toward warmer and wetter growing seasons. Heavy and extreme rainfall events are increasing in frequency and severity, especially since 2000. Heavy rainfall events, either singly or accumulated over several days, have a definite effect on soil fertility management due to the loss of essential nutrient from leaching or other factors. Soil nutrients most prone to loss are nitrogen, followed by potassium, sulfur, and the micronutrient boron. Adjustments to the management of these essential nutrients can counteract much of this potential loss.

Figure 1. The Nitrogen cycle

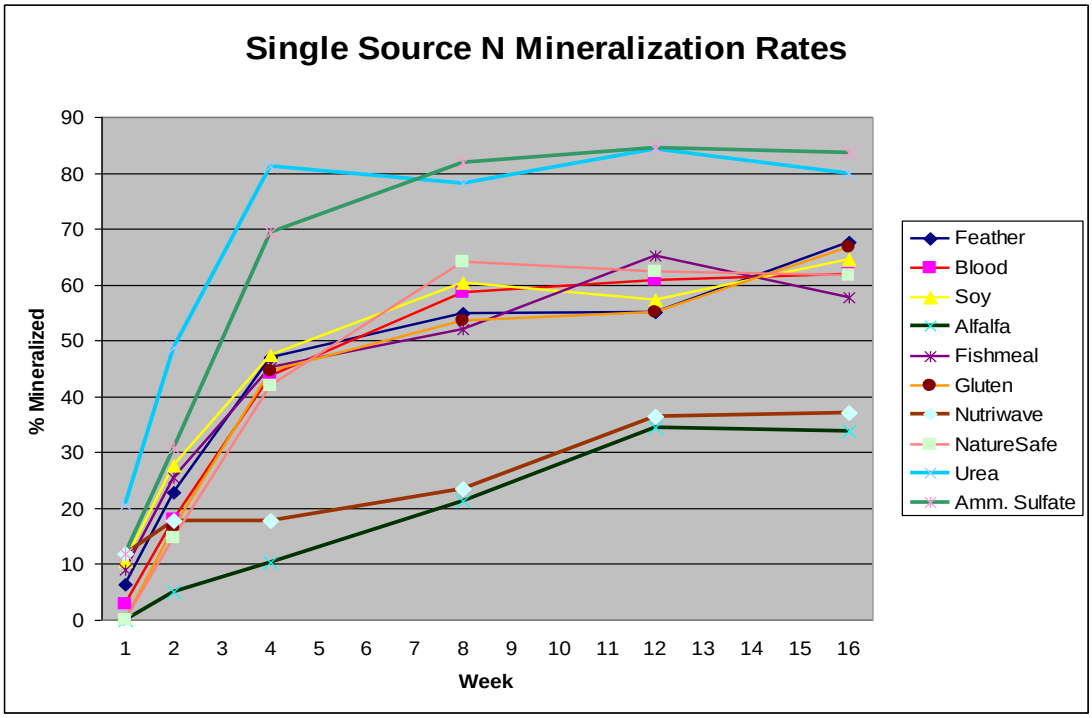


It is well known that nitrogen is the most important major nutrient affected by excess rainfall, due to multiple loss pathways. Regardless of whether the source is chemical or organic, nitrogen goes through the same biological transformation (mineralization) process from organic forms to ammonium to nitrate (Fig 1). Organic forms of nitrogen are stable and not prone to loss, but are not available for plant uptake. The intermediate form of nitrogen is ammonium (NH_4^+), which can be retained on cation exchange sites. If the initial conversion to ammonium occurs at the soil surface, some ammonium will convert to free ammonia gas (NH_3) and be lost to volatilization (evaporation). It is important that all nitrogen topdress applications (chemical or organic) be at least lightly incorporated to avoid this loss.

The final relatively rapid conversion step is from ammonium to nitrate (NO_3^-). Nitrate is a negative charged anion that does not form stable bonds, unlike other anion nutrients. So there is little or no retention capacity in the soil. Most plants require the bulk of their nitrogen in the nitrate form, but this is the form most prone to leaching loss from excess rainfall. An equally important loss pathway for nitrate is denitrification. It is common for soils under cultivation to form a hardened layer at the bottom of the tillage zone (tillage pan), restricting soil drainage. This causes the root zone to stay saturated for several days after heavy or sustained rainfall events. With all pore spaces full of water, there is not oxygen available for normal respiration of the soil microbial population. Many groups of microbes can use the oxygen in the nitrate molecule in place of free atmospheric oxygen. This converts nitrate to nitrous oxide or free nitrogen gas, which is lost to the above ground atmosphere. Denitrification can cause the complete loss of nitrate in only 1 or 2 days of saturation. Lack of free oxygen in saturated soils can also damage plant roots, which require it for normal function. This can diminish root function for the remainder of the growing season.

Timing of nitrogen applications is key to minimizing these losses and maximizing crop response. Plants do not require nitrogen at a constant level throughout the season. Nitrogen primarily feeds height and foliar growth relatively early in the season, but not until several weeks after planting. In fact, most long-season crops (including corn) do the bulk of nitrogen uptake starting 3 – 4 weeks after planting and extending to about 8 weeks after planting. Having nitrogen available as nitrate during this 4 week "uptake window" is critical. Knowledge of fertilizer release rates is necessary in the selection of the best fertilizer source of nitrogen.

Figure 2. Nitrogen mineralization rates at 60 F soil temperature



Many incubation studies have been conducted to document the release rates of both chemical and especially the non-chemical sources of nitrogen used in organic production: plant and animal meals, animal manures, cover crops, and compost. Most chemical sources release quickly, with complete mineralization to nitrate in 2 - 3 weeks after application (Fig 2). This can be overcome by using treated or extended-release nitrogen sources. Non-chemical sources take longer and are variable. Many plant and animal meals can release as fast as 4 – 6 weeks from application (Fig. 2). Others can release slowly over an entire growing season. The primary factor in determining release rate is the carbon to nitrogen (C:N) ratio. The critical break point in this relationship is a ratio of 10:1. Non-chemical fertilizers with more than 5 % N guarantee will be fast release, since both plant and animal tissue have 40-50 % carbon content. Those with less than 5 % N will release more slowly and over a longer time.

Fresh animal manures have some nitrogen already partially mineralized as ammonium when spread. This fraction will become available almost immediately. The remaining organic nitrogen will release over several weeks, with even a small release the year after application. Cover crops can release a substantial amount of nitrogen, again depending on C:N ratio. Lush green covers will release quickly, where more mature residue will release more gradually. Organic nitrogen in compost has been "stabilized" or partially degraded by microbial activity during the composting process. This causes compost to release available nitrogen very slowly, making it a relatively poor choice as a source of plant-available nitrogen.

To minimize leaching and denitrification losses of nitrogen, application timing is critical regardless of the source. Minimal nitrogen (½ or less) should be applied at planting time – especially with very fast-release chemical sources. A delayed application of ½ or more of the full season nitrogen supply should occur just before the 4 to 8 week uptake window for nitrogen. This avoids early season rainfall events, minimizing losses, while providing the bulk of the nitrogen during the period of maximum demand. Since this is a biological process, all nitrogen sources will release faster at higher soil temperatures. This is another benefit of a delayed sidedress application, when soil temperatures are higher later in the season.

Potassium is another major nutrient of concern for leaching loss during heavy rainfall events. This is of greatest concern in sandy soils. Potassium deficiency is characterized by interveinal chlorosis and then bronzing in older leaves and yellow shoulder in tomatoes. Potassium (K^+) is a +1 charge exchangeable cation, retained on negative charged surfaces of organic matter and especially on clays. Organic-based exchange sites do not hold potassium efficiently, preferring +2 charge cations like Ca^{+2} and Mg^{+2}. Clay-based exchange sites have a very high affinity for potassium, making clays the primary retention capacity for potassium. Sandy soils, with very little clay content, do not hold potassium efficiently. This results in much of the total potassium content being released into the soil water, where it is easily lost to leaching if not taken up by plants. To avoid excess loss of applied potassium in sandy soils, splitting the application (similar to nitrogen) is the best way to ensure continued availability throughout the growing season. Loamy soils, with substantial clay content, are much less prone to potassium losses. The full season requirement of potassium can be applied at planting time, with minimal leaching loss through the season.

Sulfur is a secondary major nutrient which can be prone to leaching loss, especially in sandy soils and soils high in phosphorus. As a secondary nutrient, sulfur deficiencies in crop plants are not as common as for potassium or nitrogen. However sulfur deficiencies have been increasing in the past 20 years due to greatly reduced atmospheric inputs from acid rain. Acute sulfur deficiency is characterized by overall chlorosis, similar to nitrogen deficiency. Sulfate (SO_4^{-2}) is the plant-available form of sulfur. As a chemically active anion, it is retained primarily by loose bonding on clay particle surface coatings of aluminum and iron oxides and hydroxides. This is also one of the primary retention mechanisms for phosphate (HPO_4^{-2}), since the 2 ions have similar molecular structures and charges in productive soils. Phosphate ions have a much higher affinity (binding strength) to these sites than does sulfate. So soils high in phosphorus will displace sulfate from retention sites into the soil water, where it is prone to leaching loss. Sandy soils, with little clay content, also have limited retention capacity for sulfate. For sulfur-sensitive crops (cole crops and other brassicas), sulfur applications can be split to extend availability in sandy and/or high P soils. For finer-textured soils a single application of 20-30 lb sulfur per acre at planting time should be sufficient. Sources include OMRI-approved potassium fertilizers Sul-Po-Mag or Sulfate of Potash. Chemical sources include Ammonium Sulfate (21-0-0) and (single) Superphosphate (0-20-0).

Boron is a micronutrient, needed in very minute quantities by all growing plants. However, unlike copper, iron, manganese, and zinc, there is no natural source of boron in our soil mineralogy in the Northeast. The plant-available form of boron is the anion borate (BO_3^{-3}), which has limited retention capacity in the soil – especially sandy or low organic matter soils. In that aspect, it is very similar to nitrate and very prone to leaching loss. Crops sensitive to boron deficiency include beets, turnips and other brassicas. Boron is important in cell elongation during stem growth. Deficiency symptoms include shortened stem internodes, thickened and curled leaves, and hollow heart of broccoli, cauliflower, and celery. Boron applications can be split for sensitive crops on sandy soils. OMRI sources of boron include Kelp meal and Greensand. The primary chemical source is Borax (sodium borate), which must be used with e**xtreme** caution, since even a minor over-application can be toxic to any plant. Safe application rates are 1 – 2 pounds of actual boron per acre (10–20 lb borax/A or 4–8 ounces/1000 sq ft). Boron deficiency can also be effectively treated by foliar spraying of borax.

Extreme rainfall events can raise havoc with a crop fertility program. Flexibility in application timing and the proper selection of nutrient sources with known release rates can go a long way toward minimizing nutrient losses, while still maximizing yields. Improving overall soil drainage by growing cover crops to promote soil crumb structure and eliminating tillage pans will help to maintain root health and function. This will make your crops better able to tolerate our increasingly erratic weather patterns.

The New Kid on the Kernal, Tar Spot of Corn

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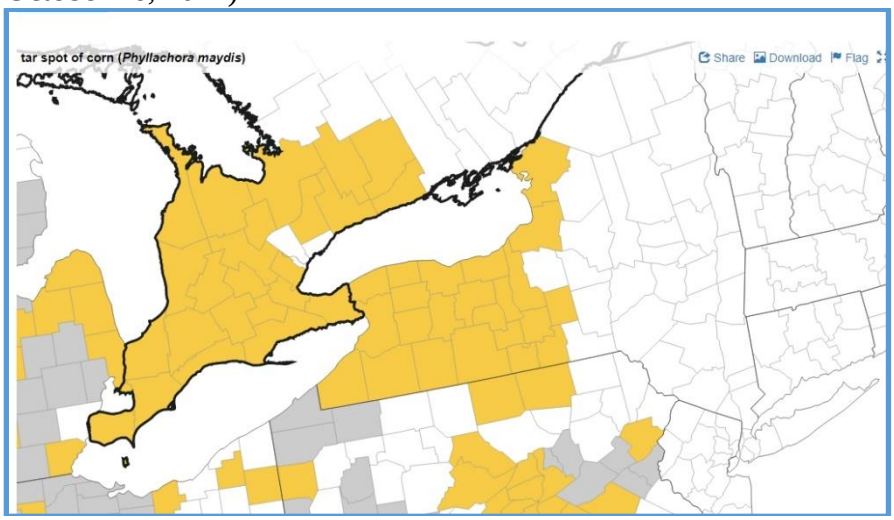
Background

Tar spot is an emerging and newly endemic disease of sweet corn, caused by the fungus, *Phyllacora maydis.* The disease was introduced into the United States from Mexico and first affected field corn in IN and IL in 2015. For NY, tar spot was first detected in western region in 2021, and this year has spread to all counties in the western and central regions. Surveys in 2023 and 24 evaluated 26 processing fields across four counties and the disease was found in 20 (77% of scouted acreage). Tar spot was also found on the foliage and husks of fresh market sweet corn in Chautauqua, Genesee, Niagara, and Erie counties during routine pest scouting.

In sweet corn, tar spot causes crop loss by contributing to defoliation, reducing the size and affecting the shape and uniformity of ears, reducing the recovery of kernels for processing sweet corn, and reducing the marketability of ears by unsightly tar spots on the husks. Selling affected ears as husked cobs requires additional labor and equipment and is only suitable for niche markets.

Fig. 1. Counties marked in yellow designate those where tar spot was detected in 2024 (as of October 16, 2024)



Symptoms

Tar spot symptoms are raised black spots typically 1/16th to 3/4th of an inch in diameter that occur randomly on the leaf and have a ‘tarry’ appearance visible on (Fig. 2). These black spots can also appear on corn husks and leaf sheaths impeding marketability. In addition to the black spots, tan to brown lesions with dark borders (‘fisheyes’) may also appear around the fungal structures. The black spots may be mistaken for older common rust pustules (which progress

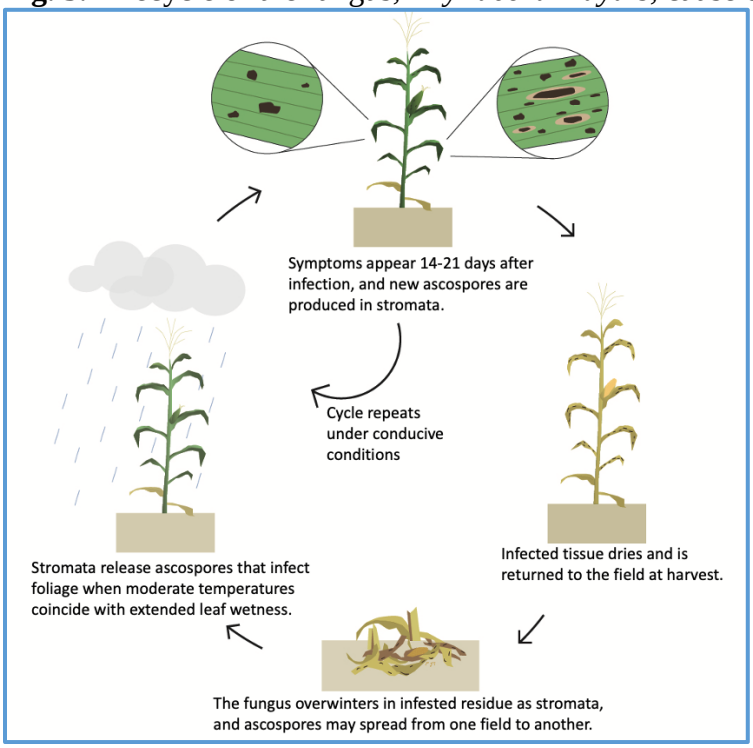
from orange-red to black with age), or insect droppings. Insect droppings can be differentiated from tar spot by appearing on only one side of the leaf and may easily be scraped off. Tar spot lesions cannot be scraped or washed off and are typically raised from the leaf surface.

Fig. 2. Tar spot symptoms on corn leaves.

Disease spread

The black 'tar' spots contain spores responsible for dispersal of the pathogen by wind and rain, including over long distances between fields (Fig. 3). The tar spot pathogen survives between seasons on infested sweet and field corn residue in Northeastern U.S. conditions. The pathogen is not seedborne and there are no alternative hosts. Therefore, the disease is **only found in field and sweet corn**. During the growing season the disease is made worse by relative humidity >75%, foggy days, and dew periods longer than 7 hours, typical of NY in late summer. Disease spread can be very rapid during this time. Canopy closure also modifies the environment making conditions conducive for the disease.

Fig. 3. Lifecycle of the fungus, *Phyllacora maydis*, cause of tarspot of corn.



Management

The addition of tar spot into the sweet corn disease complex has changed the dynamics and increased risk of crop loss due to defoliation and reduced product quality.

- **Residue management:** Incorporate corn residue into the soil after harvest to encourage decomposition. The fungus survives on corn residue but not in the soil.
- **Crop rotation:** Although there is a considerable amount of corn in the farming landscape, crop rotation away from corn for at least 3 years will assist in reducing inoculum for subsequent crops.
- **Cultivar selection:** Currently most sweet corn hybrids are highly susceptible but susceptibility varies between locations. Check with your seed supplier for the latest knowledge on cultivar susceptibility to tar spot and any experiences in your area.
- **Site selection:** Pick a site with good airflow to minimize relative humidity within the canopy late in the season.
- **Fungicides:** May be effective at the tassel emergence to blister stage and R2 (1 to 2 applications). Strobilurins (Fungicide Resistance Action Committee Group 11) and demethylation inhibitors (FRAC Group 3) are efficacious for tar spot, Northern corn leaf blight and common rust. Check with your local state regulations for registered products approved in your area.

Covering Ground: Interseeded Cover Crops in Late Season Sweet Corn

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Due to the short growing seasons in Northern New England, cash crops are often harvested too late to establish a cover crop after harvest and prior to the winter. This study aimed to evaluate the effects of different cover crop planting dates and cover crop planting methods on sweet corn yield, cover crop biomass, and weed biomass. This research was conducted to provide evidence-based recommendations to farmers in the Northeast region who interseed or intend to interseed cover crops over sweet corn cash crops now or in the future. In addition to our research-farm based replicated trials, we worked with collaborating farms to trial this practice with a number of different sweet corn production approaches and available equipment.

MATERIALS AND METHODS

Trial: Cover Crop Timing and Seeding Methods

Treatments: Our replicated research trials included the following treatments: (a) timing of seeding cover crops in relation to the development of the sweet corn crop (main-plot treatment), and (b) seeding method (subplot treatment). Our timing treatment (a) includes planting a cover crop of annual ryegrass and crimson clover mixed (25 lb/A 60% ryegrass:40% clover), when the sweet corn reached maturity stages V3, V5, and V7 with an additional post-harvest cover crop planting date serving as a control. Within those treatments, we tested the effects of different planting methods (b); broadcasting seed, broadcasting and incorporation using a hand rake, and drilling the seed between crop rows with an Earthway® push seeder.

RESULTS AND DISCUSSION

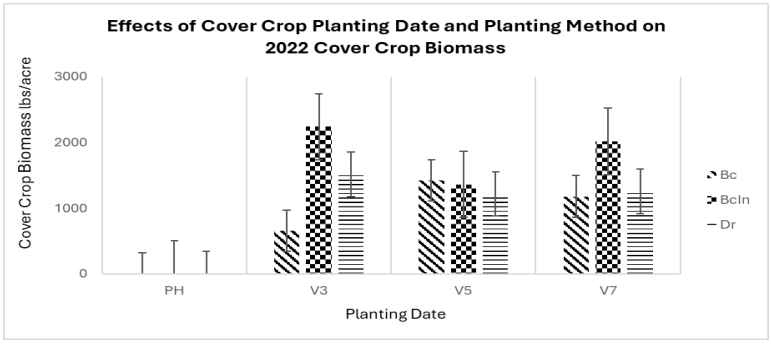
Sweet Corn Yield

At the time of writing this proceeding, corn yield is still being analyzed and will be ready by the time of the conference. Our observations showed little difference in the quality and maturity of the crop between treatments.

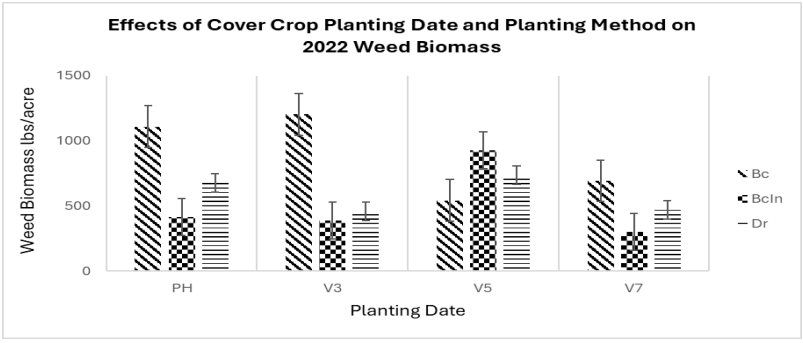
Cover Crop Biomass

In 2022, the highest season end cover crop biomass was observed in the Broadcast and Incorporate (BcIn) method at the V3 stage, indicating that early seeding increased biomass production, however few significant differences were observed among the rest of the treatments. 2022 was a particularly dry year and many of our seeding dates passed with no measurable

rainfall. Upon receiving rain, many of the plots germinated at a similar time, leading to a lack of difference in the collected biomass. Note the particularly low biomass in the V3 broadcast treatment. This experienced a longer duration of time with no rain (V3), and the seed was left to desiccate on the soil surface. Rainfall was more consistent in the 2024 season, leading to a clear and observable difference in cover crop biomass and growth. The earlier seeding dates (V3) grew well prior to canopy closure and light exclusion, while V5 had slightly less growth. The V7 plots were just germinated prior to dormancy under the canopy of the corn crop. While V5 and V7 biomass was suppressed during the growing season, upon post-season mowing of the corn stalks the cover crop in those plots did develop rapidly prior to winter. The BcIn method proved particularly effective, as it ensured better seed-to-soil contact promoting germination and growth rates. While the Drilling (Dr) method also produced substantial biomass at the V3 stage, the overall advantage of the BcIn method was evident in 2 of the 3 seeding timing treatments. Perhaps more importantly, the use of broadcasting and incorporating seed is far more practical on farms and can be matched with fertilizer side dressing operations. Our 2024 data (to be presented at the conference) highlight the critical role of both planting timing and method in optimizing cover crop biomass. Logistically, most producers will find that broadcasting seed can be done easily while drilling over standing corn requires specialized equipment.



Weed Biomass



In 2022, the lowest weed biomass was observed in the Broadcast and Incorporate (BcIn) method at V7. Conversely, the Broadcast (Bc) method produced the highest weed biomass at V3. The broadcasted cover crop seed in the dry conditions of 2022 was slow to germinate, being left on the soil surface, leading to little competition to suppress weeds.Additionally, the early seeding date meant that no further weed management could be accomplished after seeding the cover crop. The data shows that planting at the V7 stage generally resulted in lower weed biomass and

this is due to the management of weeds later in the season. Although early planting at the V3 stage allows for initial establishment, it may lead to more weed seed set as weed control operations cannot occur after the cover crop is seeded. For weeds that grow past the cover crop, this creates a longer window with no weed management options and more time for weed growth and development. The BcIn method consistently yielded lower weed biomass compared to the Bc and Dr methods which could be attributed to better soil coverage and competition from the cover crops which create a physical barrier that prevents weeds from germinating. Overall, the data underscores the importance of planting date and method in managing weed biomass. Later planting and soil incorporation are crucial strategies for optimal weed suppression, guiding informed decisions in cover crop management to enhance weed control. Note the converse relationship between cover crop biomass and weed biomass, showing that the interseeded cover crops effectively suppressed weeds in relation to their level of development.

On-Farm Trial Logistics and Experiences

The farmer collaborators involved in this project had success with this approach using a variety of equipment and approaches. One large scale farm owns a Gandy^{R} Orbit Air sidedress applicator designed for side dressing fertilizer between 6 rows of corn per pass. This allows them to distribute seed and fertilizer in one pass, and incorporate those with the attached lilliston cultivators. Another farm uses both spin spreaders, or an old seed drill with high clearance. With the drill they removed 2 seeder units over both rows of corn, leaving the remaining units for drilling seed between the rows. While this unit worked well in dry seasons due to the enhanced seed to soil contact, the farm leaned towards spinning the seed on just prior to the last cultivation due to the ease of application. A third farm trialed mixing seed with urea fertilizer in a 3-point cone spin spreader when sidedressing followed by cultivating with a second pass. This worked well, however in the 2nd season this farm attached a Gandy^{R} Sidedress hopper to the belly mount on an IH200 tractor with side-knives and lilliston cultivators. This allowed them to complete the seed application and incorporation in one pass. All farms preferred the annual ryegrass and crimson clover mix (25 lb/A 60% ryegrass:40% clover). All farms had success with the system when applying seed at sidedressing, which also corresponded with the last available time for tractor operations in the field due to the height of the crop. While the primary goal of this project was to enhance cover crop establishment in these fields going into the winter, observations from these field demonstrations showed benefits of soil stabilization and erosion prevention after extreme mid-season rainfall events, and better access and reduced muddiness in the field after rainfall events due to the root mass and soil coverage from the cover crop.

Conclusion

The findings demonstrate that the Broadcast and Incorporate (BcIn) method can increase cover crop seed germination and reliability in dry years. Planting cover crop seed at the V3 stage maximizes biomass production due to optimal growing conditions, including sufficient sunlight and moisture. However, some farmers would prefer a slightly lower amount of cover crop biomass to ensure that the cover crop is not competing with the crop for nutrients and water. Early planting of cover crops reduces access to the field for weed suppression. Our trials demonstrated significantly reduced weed biomass when the seeding time was delayed to the V5 stage, or when many farmers are applying sidedress fertilizer. Planting cover crops at the V5

stage using the BcIn method, results in better weed suppression, cover crop establishment, with no effect on corn yield. This trend emphasizes the importance of planting timing and method in managing both cover crops and weeds biomass.

Production Options for Matted Row Strawberries

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The matted row has been a successful and profitable strawberry production system in New England for many years and is still widely used because of this. Advantages of the matted row over other, higher input systems include its relatively low initial investment costs, its adaptation to cold climates, and the ability to maintain the planting for several years. The system works well because it exploits the natural growing habit of the strawberry plant, optimizing both its vegetative characteristics and its fruiting potential to produce a profitable crop with a relatively low level of inputs.

Preparing the Soil

Getting ready for strawberry planting may take two years, depending upon the condition of the site. Have the soil tested for pH and fertility. Fertilizer can be applied and worked into the soil prior to planting, or banded into the soil after planting. Rates should be determined through soil tests taken the previous fall. In general, a rate of approximately 30 lbs. of nitrogen, 60 lbs. of phosphorus (P_20_5) and 60 lbs. of potassium (K_2O) should be incorporated into the soil prior to planting (e.g. 300 pounds/acre of 10-20-20 or its equivalent). An additional 30 pounds of nitrogen per acre (e.g. 65 lbs. urea) should be applied over the plants in July to promote runner development. Another, lighter application of nitrogen may be applied in August to aid in flower bud development (e.g. 40 lbs. urea).

Planting and First Season Care

Plant strawberries in the spring as soon as the soil can be prepared. Purchase only certified disease-free plants from a reputable nursery. Plants should have large crowns and lots of healthy, light-colored roots.

Matted rows may be established on raised beds. In most situations raised bed are an advantage; they better define the row width for bed establishment, they improve drainage and air circulation, reducing disease problems, and they makes harvesting easier. Raised beds should be six to ten inches high, and one to two feet across. The disadvantages of raised beds include added labor and equipment costs, and an increased potential for drought and winter injury to the plants.

Strawberries should be planted deep enough to bring the soil half way up the compressed stem or crown. Pack the soil firmly around the plants, and irrigate immediately after planting.

The strawberry crowns should be initially planted 18 inches apart within rows, with 48 to 52 inches between rows. This will require about 7300 crowns per acre. These plants will produce runners during the summer that will root and fill out the rows. The width of the plant row should be limited to 24 inches to maintain easy access in the planting. Runner plants that grow outside the 24-inch row width should be pinned back into the row or removed if the plants become too

crowded. Closer plant spacings (eight to ten inches) and double rows are sometimes used to increase plant density in hopes of increasing first harvest yields by having a higher population of mother plants vs. daughter plants. Having a high initial plant density may also make harvesting the crop in the planting year economically feasible, rather than picking off the blossoms to encourage runner plant development (see below). However, in most scenarios, the added cost and labor of high density plantings negates any increase in overall profitability of the planting

All flower blossoms that emerge during the planting year should be pinched off. This encourages runner growth and plant vigor and leads to better yields next year. Because of the initial wide spacing of the crowns the planting year crop would be very small, difficult to harvest and thus of little value.

Mulching

Mulch is typically not applied to strawberry beds until late in the fall for winter protection. However, some growers are trying planting through plastic mulches to encourage early growth and reduce weed problems. Planting strawberries through black plastic eliminates much of the weed pressure within the planting, but inhibits rooting of runner plants to fill in the rows. Cutting the plastic when runner start to emerge to allow the runner plants to root or removing the plastic completely is labor intensive, but having the plastic in place during early establishment to prevent the first flush of weeds may make it worthwhile. Biodegradable plastic mulches may also be applied at planting to reduce weed emergence. These products are more expensive than conventional plastic, but offer the advantage of breaking down in the field after two to four months, allowing the runner plants to root without having to remove the mulch.

Clean straw mulch should be applied over matted row strawberries after the plants have gone dormant in the late fall to protect the plants from extreme winter cold and from damage to the roots caused by rapid freezing and thawing of the soil. Two to five tons of straw per acre is recommended (approximately one ton of straw provides one inch of coverage per acre). Use the higher rates if your fields are exposed and do not get consistent snow cover. The mulch layer should be approximately 6 inches deep over the plants. Be discriminating about your source of straw. Straw from weedy fields will result in weed infestations in your strawberries.

Heavy weight fabric rowcovers may also be used for winter protection. Initial costs of these materials are high, and they do not over the weed control that straw mulch provides the following spring. However, they may be a good alternative when good quality, affordable straw mulch is not available, and they can be managed to encourage early crop ripening. In the early spring (late March-early April) the mulch should be pulled off the plants and placed into the aisles between rows. This creates a clean walkway and keeps the fruit dry and clean.

A light application of fertilizer may be applied after mulch removal to stimulate spring growth. Only 10 to 15 lbs of actual nitrogen is recommended to prevent excessive vegetative growth at this time, which can lead to fruit rot problems (e.g. 85 lbs./acre of calcium nitrate). Light applications (1 to 2 lbs./acre) of boron are also often applied in the spring to help fruit development.

Frost Protection
If a frost is predicted after the mulch has been removed irrigation should be set up to protect the flower buds. Set up sprinklers to provide complete coverage of the planting, and turn the water on when the temperature drops to 33° F. Continue to run the water until all the ice formed on the plants has completely melted. Frost nozzles are available for sprinklers that will provide protection using less water than regular nozzles, saving energy and preventing flooding.

Fabric, "floating' row covers may also be placed over the plants to provide and frost protection. Rowcovers should be placed over the plants in the early fall. The plants and rowcovers may be covered with straw in late fall for additional winter protection. Remove the straw in early spring, or as soon as the snow melts. Leave the rowcovers on until the plants begin to bloom. This may occur 2 to 3 weeks earlier than plants without rowcovers, so you must be prepared to protect the flower buds from frost. Although the rowcovers will provide some frost protection, it is best to use irrigation over the rowcovers if the temperature drops below 30°F. Row covers may also be applied only in the early spring and removed when flowers first appear. This avoids the problems of trying to maintain the rowcovers over the winter, but the increased yield effects tend to be reduced.

Renewing the Planting
Strawberry beds can usually be carried over for three to five years. Annual bed renovation is a critical part of successful strawberry production with the matted row system. Renovation is primarily a plant thinning process carried out after harvest to stimulate healthy new vegetative growth. A strawberry bed that has had a productive season and has vigorous plants free from serious insect, disease, and weed problems should be carried over for another year. All beds to be carried over should undergo the following steps beginning soon after harvest is complete.

1. Broadleaf Weed Control: If perennial broadleaf weeds (dandelion, daisy, etc.), and/or a high population of emerged annual broadleaf weeds (lambsquarter, pigweed) are present 2,4-D amine (Amine 4®) can be applied for control. 2,4-D is a post-emergent herbicide, which is effective on broadleaf perennial weeds. It will not control grasses, nor does it offer any pre-emergent control. If 2,4-D is not applied all broadleaf perennial weeds should be removed by hand.

2. Mowing: If 2,4-D was applied to the planting, wait four to five days following the application then mow off the leaves of the strawberries about 1 1/2 inches above the crowns. The leaves can be mowed immediately after harvest if 2,4-D is not applied. Mowing stimulates new leaf growth and may provide control of leave diseases.

3. Fertilization: Typically, about 40 pounds of actual nitrogen per acre is applied at this time (e.g. 87 lbs. of urea), with another 20 pounds of actual nitrogen applied four to six weeks later. Balanced fertilizers, such as 10-10-10, containing phosphorus and potassium may be used if soil tests indicate a need for these nutrients. Tissue nutrient analysis of leaves after renovation can offer more precise guidance to appropriate fertilizer rates for each field. A very light application of nitrogen is often applied the following spring after removal of the mulch. Ten to 15 pounds of actual nitrogen at this time can help to stimulate early plant growth. Heavier applications should be avoided because this could cause excessive vegetative growth and increase the likelihood of

fruit rot. Light applications of boron (1 to 2 lbs. per acre) and calcium may also provide some benefit to fruit development in the spring.

4. Plant Thinning: Strawberry rows should not be allowed to get more than 24 inches wide. Till the sides of the rows to narrow the beds back to a width of ten to twelve inches. Set the tiller so it incorporates the mowed leaves and fertilizer, and spreads about one inch of soil around the remaining crowns. During the summer, new daughter plants should be allowed to root to fill out the row to the desired 24-inch width. Some growers are using contact herbicides with a shielded sprayer or shielded flaming to narrow the plant rows, rather than tillage. This reduces weed seed germination by leaving the soil surface undisturbed, but doesn't allow for the incorporation of fertilizer or the buildup of soil around the crowns.

5. Pre-emergent Weed Control: To control annual weeds, terbacil (Sinbar 80WP) may be applied according to label directions. Be sure to read and follow all precautions on the label.

6. Irrigation: Encourage optimal plant growth and get the most out of your fertilizers and herbicides by regular irrigation. Strawberries will grow best if they receive 1 1/2 inches of water per week during the growing season.

Do not delay the renovation process. Late renovation will delay the rooting of new runners needed to reestablish the bed. This will result in smaller plants and lower yields next year. Be vigilant! Be on the lookout for weeds, insects, spider mites and diseases throughout the year. Cultivation and/or sprays are likely to be necessary as the summer wears on.

Beds that will not be renovated and carried over should be plowed down and seeded to a suitable cover crop to reduce weed, insect and disease problems that have developed and to increase soil organic matter content. 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.

Growers who want to produce strawberries organically often forego the renovation process and simply plow the bed down after the first fruiting year, and have another bed planted that spring to harvest the following year. This prevents the build up of weeds in a field that will usually occur without the use of herbicides. While planting beds every year and not carrying over them beyond one harvest may cost the grower a bit more, the profit margin of a well-run organic strawberry bed can still be good.

For more detailed information on strawberry production, see the ***Strawberry Production Guide for the Northeast, Midwest and Eastern Canada***, published by the University of New Hampshire Cooperative Extension (https://extension.unh.edu/resource/strawberry-production-guide-northeast-midwest-eastern-canada-2nd-edition).

Weed Management Update for Strawberries

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Weeds remain a major challenge in strawberry 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 makes strawberry plantings more prone to the development of hard-to-control perennial weeds. Additionally, the number of herbicides labeled on strawberry is limited compared to row crops because of the high potential for strawberry injuries. Thus, efficient weed management strategies will rely on various control measures that need to be tailored to weed populations that are specific to your strawberry crop. This presentation will cover the basics of a successful weed management program from proper weed identification to the selection of appropriate herbicide tools to control challenging weeds.

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

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

Weed Control

FACTORS AFFECTING THE EFFICACY OF HERBICIDES

- Target – Is herbicide labelled for the targeted weed species?
- Soil properties – Is the selected rate appropriate to soil texture and organic matter content?
- Timing - Is herbicide used at the right time in relation with crop and weed phenology?
- Activation - Has preemergence herbicide been activated with sufficient rainfall?
- Persistence - How is irrigation affecting the persistence of active ingredients?
- Resistance – Has the targeted weed developed resistance to the active ingredient?

- **Pre-planting** herbicide application is important to control established perennial weeds such as Canada thistle, red sorrel, quackgrass or goldenrod. Glyphosate remains the most effective herbicide for perennial weed control when applied in fall prior to planting. Spray in early to mid-fall but before the 1st frost and before weed leaves start changing color. Glyphosate is a slow acting herbicide and results may not be visible before 10-15 days. Spring application of glyphosate will not provide effective control of established perennials because of reduced herbicide translocation to underground storage organs.
- **Fumigation** is essential to control weeds because labeled preemergence herbicides cannot be applied over the top of plastic mulch. The most effective soil fumigation is a sequential application of chloropicrin followed 5 to 7 days later by metam-sodium or metam-potassium. Fumigants before bed preparation will kill the seeds of most annual and perennial weed species, but may not be sufficient for killing rhizomes or tubers of perennials. Thus, it is essential to achieve good control of perennials with glyphosate before planting. However, to kill weed seeds, fumigants need to penetrate the seed coat, which can only be achieved if seeds are sufficiently moistened to allow the penetration of the fumigant. Proper irrigation before fumigation and soil temperature above 55°F are critical factors for achieving effective weed control. Additionally, pre-irrigation may stimulate the germination of non-dormant wee seeds, and the emerging seedlings will be more readily killed by fumigation than at the seed stage.
- **New plantings**
  - **Soil applied herbicides** labeled for new plantings include DCPA (Dacthal), terbacil (Sinbar), pendimethalin (Prowl H2O), and napropamide (Devrinol). DCPA and napropamide can be applied at transplanting or during the early growth stage of strawberry. Terbacil can be applied after transplanting but before new runner plants start rooting. If transplants are allowed to develop new foliage prior to terbacil application, the spray must be immediately followed by at least 0.5" of irrigation to prevent severe injury. Terbacil should be used only on soils containing more than 0.5% organic matter, and at the lowest labeled rate on sandy soils. Sinbar should never be used with any tank mixed surfactant as this may increase the risk of crop injury. Pendimethalin (Prowl H2O) is also labeled on new plantings for preemergence control of grasses and small seeded broadleaf weeds. Pendimethalin should not be applied over the top of strawberries once they start developing new foliage as severe injury may occur. All preemergence herbicides should be activated

(penetration into the soil) with at least 0.5" irrigation or rainfall within 24-48 hr after application.

- **Postemergence herbicides** include graminicides such as clethodim (Select), fluazifop (Fusilade), or sethoxydim (Poast) that can be used with nonionic surfactants for controlling actively growing grasses no taller than 6". Clopyralid (Stinger) has a 24c Special Local Need label in NJ, NY, and PA for controlling many weed species in the composite and legume families (thistles, ragweed, dandelion, horseweed, clover), and also nightshades and smartweeds. Only post-harvest (late July) applications are recommended for clopyralid in new plantings.
- **Late fall dormant** applications of napropamide, terbacil, or DCPA before mulching will provide efficient control of many winter annual weeds through springs, and will allow spring preemergence herbicide to be more effective by maintaining the soil clear of weeds at the time of application.

- **Bearing years**
  - **Soil applied herbicides**: in addition to herbicides used for new plantings, flumioxazin (Chateau) is also labeled on established dormant plantings and will provide excellent control of many grasses and annual broadleaf weeds. 2,4-D amine (Weedar 64) is a postemergence herbicide that can be applied in late winter or early spring when strawberries are still dormant for successful control of broadleaf weeds.
  - **Post-harvest renovation** is a good time for applying clopyralid or 2,4-D amine since strawberries are in a semi-dormant stage and are less sensitive to herbicide injury. However, 2,4-D amine should not be applied after mid-August as it may affect flower bud formation in late summer, resulting in distorted strawberries the following year. Renovation is also a good time to re-apply preemergence herbicide such as terbacil or DCPA to suppress new flushes of weed germination throughout the summer.
  - **Late fall dormant** applications for established plantings are similar to those described for new plantings.

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

Research-Driven Solutions for Improved Temperate Fruit Production and Profitability

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The USDA-ARS Appalachian Fruit Research Station (AFRS) in Kearneysville, WV opened in 1979. Forty-five years later, this research facility maintains a vibrant, forward-thinking national mission with ~60 full-time staff, state of the art molecular, bioinformatics, tissue culture, and growth chamber facilities, and over 500 acres of land for experimental orchard plantings. U.S. temperate fruit production is under increasing pressure from invasive and persistent native pests, emerging and persistent phytopathogens, regulatory changes, and a lack of genetic diversity. Climate change is leading to erratic weather patterns that are shifting pest phenology and overall densities, increasing disease incidence and severity, and leading to declines in tree health due to unpredictable episodes of drought, water-logging, and frost. These challenges have been compounded by pesticide resistance issues, resulting in inherent weaknesses in management programs At the same time, changes in market conditions, consumer preferences, shrinking availability of land and labor, and reduced farm profitability have prompted the need for innovations that better enable sustainable production practices, mechanization, and higher returns on investment.

Currently, there are significant knowledge gaps about major fundamental aspects of tree biology that hamper our ability to make key genetic improvements, including tree architecture, dormancy and bloom time, and fruit development. Scientists at the AFRS are employing breeding, genetics, and biotechnology strategies to fill these knowledge gaps and develop superior germplasm. They are studying unique stone and pome fruit germplasm carrying novel traits such as pitless, altered dormancy and bloom time, and architectural variations to identify the causative genes and associated pathways. And traditional and advanced breeding technologies are being used to introgress and stack commercial traits that confer improved tree architecture, climate resilience, disease resistance, and superior fruit quality into parental and commercial germplasm.

Our scientists are developing affordable and scalable technologies for precision management of necessary water and nutrients well as for monitoring and management of pests and diseases of temperate fruit production. We are learning more about root phenotypes, rootstock-conferred above-ground traits, relationships among tree physiology, fruit quality, and pest and disease prevalence, and developing affordable plant phenotyping systems to accelerate selection and breeding efforts. Finally, we are assembling the first-ever carbon-footprint and sequestration potential of orchard crops to support climate-driven agricultural systems. These interconnected research technologies and knowledge products will enable the industry to grow, store and market high-quality temperate fruit and contribute to climate-smart agriculture.

Thinning Apples with Metamitron (Brevis®) and Accede®

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Introduction

Managing fruit load is a critical, yet challenging practice for growers involved in apple cultivation because setting more fruits than desired will directly affect fruit size and quality and may lead to biennial bearing. Chemical thinning is the preferred method to achieve this because fruit can be removed shortly after bloom, resulting in a greater impact on fruit size at harvest compared with hand-thinning later in the season.

In North America, carbaryl is a widely used chemical thinner, but because of potential negative impacts on human health and toxicity to bees, it is not registered as a fruitlet thinner in Europe. In Canada, carbaryl has recently undergone risk assessment by the PMRA, which has further restricted its use and re-entry periods.

Finding alternatives to carbaryl has led to interest in studying new thinning products and more predictable thinning strategies. Metamitron, formulated as Brevis (Adama Agricultural Solutions Canada Ltd) and 1-aminocyclopropane carboxylic acid (ACC), formulated as Accede ™ (Valent BioSciences) are two compounds that are currently being evaluated for thinning efficacy by our program. One of several aspects of our research is to investigate the optimal fruitlet size at which to apply these two new compounds because sensitivity to chemical thinner changes as fruits develop. Other research objectives that we have investigated with respect to metamitron include the influence of surfactants, rate, and single vs multiple applications on thinning efficacy, however space does not permit these to be included in this report.

Methods

A 4-year-old spindle research orchard of Brookfield Gala/M.9 rootstock located at the University of Guelph, Simcoe Research Station was used. Planted in 2018, trees were trickle irrigated and spaced 2.5 m x 4.5 m (889 trees/ha). This orchard was used for four experiments between 2021 and 2022. In 2021, two experiments were conducted in a randomized complete block design with five replications and six fruitlet timing treatments applied to single tree plots. Experiment 1: treatments consisted of an untreated control and 438 mg/L metamitron applied at 7 mm, 11 mm, 15 mm, 18.5 mm, and 22.5 mm fruitlet diameter. Experiment 2: treatments consisted of an untreated control and 400 mg/L ACC applied at 7 mm, 11 mm, 15 mm, 18.5 mm, and 22.5 mm fruitlet diameter. A non-ionic surfactant (Regulaid, Kalo, Oveland Park, KS) 0.05% (v/v) was included in treatment to improve product absorption. These experiments were repeated in 2022 at slightly different stages (diameters) of fruitlet development.

Treatments were applied using a commercial air blast sprayer at 1379 kPa, 388 L/ha, which equated to tree row volume (TRV) pesticide dilute. To minimize treatment interference caused by spray drift, experimental units were separated by at least one guard tree to minimize treatment interference caused by spray drift.

Horticultural Measurements

Fruit set was determined on two main scaffold branches on both the east and west sides of each tree and averaged to calculate percent fruit set. Total fruit weight and number of fruit per tree was recorded at harvest (Sept. 13, 2021, Sept 12, 2022). The number of unmarketable fruits (undersize, poor colour, premature fruit drop) were also counted and weighed. Mean fruit size was estimated by dividing total fruit mass of marketable fruit by the number of fruits in the sample. All the apples from each tree were graded using a commercial colour sorting and sizing line in Dec. 2021 and Nov. 2022. The trunk cross-sectional area (TCSA) was used to calculate crop load, which is expressed as the number of fruits per trunk cross sectional area. Tree trunk circumference at 30 cm above the graft union was measured at the beginning and end of each growing season.

Results

Metamitron Experiments

In 2021 and 2022, there was a significant treatment effect on fruit set ($P<0.0001$) in the metamitron experiments. The untreated control and the treatment with metamitron applied when fruitlet size was 22.5 mm in 2021 and 23.5 mm in 2022 had the highest fruit set. In 2021, metamitron applied at 11 mm followed by metamitron applied at 18.5 mm resulted in the lowest fruit set. Metamitron applied at 11 and 15 mm resulted in 79% and 40% reduced fruit compared to the untreated control, respectively. In 2022, metamitron reduced fruit set the greatest when applied at 14.5 mm (60% reduction) followed by 18.5 mm (47% reduction) fruitlet diameter compared to the untreated control ($P=0.001$). Fruit set on trees treated with metamitron at 5-, 8-, and 23.5-mm fruitlet diameter was similar to the untreated controls.

In 2021, metamitron treatments significantly influenced the number of fruits per tree fruit ($P<0.0001$), total yield per tree ($P<0.0001$), mean weight of marketable fruit ($P<0.0092$), and crop load ($P<0.0001$). The number of fruits per tree followed a similar trend as the total yield with the highest number of fruit and total fruit yield observed on the untreated control trees, followed by metamitron applied at 22.5- and 7-mm. The number of fruits per tree when metamitron was applied at 11-, 15- and 18.5-mm was 75%, 57% and 67% lower than the untreated trees, respectively. There was also a significant treatment effect on marketable fruit weight ($P=0.0092$); metamitron applied at 11 mm resulted in the greatest fruit weight (181g) but when applied at 18.5 mm resulted in the lowest fruit weight (135g). Applications of metamitron between 11- and 18.5 mm resulted in significantly lower yields compared to the untreated control. Crop load was reduced with metamitron applied between 11- and 18.5-mm in comparison to the untreated control.

In 2022, metamitron treatments also significantly affected the number of fruits per tree fruit ($P<0.0001$), total fruit yield per tree ($P<0.0001$) and crop load ($P<0.0001$). Trees treated with metamitron at 14.5- and 18.5-mm resulted in the fewest number of fruit per tree, lowest total

yield, greatest fruit weight and lowest crop load. In contrast, trees treated with metamitron at 5-mm, 8- mm, and 23.5-mm fruitlet size had similar number of fruits per tree and crop loads as the untreated control, indicating the poor response of Gala to metamitron when applied at these fruitlet stages.

ACC Experiments
In 2021 and 2022, there was no significant treatment effect on fruit set ($P<0.0001$) in the ACC experiments. In 2021, there was no significant treatment effect of ACC on the number of fruits per tree, total yield per tree and fruit weight, or crop load. However, in 2022, there was a significant treatment effect of ACC on the number of fruits per tree ($P=0.0044$), total fruit yield ($P=0.0174$), mean weight of marketable fruit ($P=0.0234$) and crop load ($P<0.0034$). ACC applied at 18.5 mm resulted in the fewest number of fruits per tree, lowest total yield and crop load. There was no treatment effect of ACC on fruit weight at any of the application timings when compared to the untreated control. Trees treated with ACC at 18.5 mm decreased the total number of fruits per tree by 29% and crop load by 28% compared to the untreated control.

Conclusions

Metamitron- Metamitron applied at 438 mg/L when fruitlets were between 11- and 18.5-mm reduced fruit set, number of fruit per tree and crop load of Gala trees in both years. Applications made at 5-, 8- and 23.5-mm fruitlet diameter were ineffective at thinning in this two-year study. In 2021, fruit weight was 14%, 18%, and 15% higher compared with the untreated control when 438 mg/L metamitron was applied at 7-, 11- and 15-mm, respectively. Metamitron applied at 18.5- and 22.5-mm decreased fruit weight by 12%, and 5% compared to the untreated control, respectively.

In 2022, when metamitron was applied at 5-, 8-, 14.5-, 18.5- and 23.5-mm, fruit weight increased 4%, 12%, 17%, 11% and 6% compared to the untreated control, respectively. A high rate of 438 mg/L metamitron was used to ensure adequate treatment response at the various fruitlet stages in this study. However, lower rates should be considered commercially when less thinning is required (subject to Brevis registration). Metamitron can be an effective thinner when used alone, but when higher thinning is required, should be used in combination with 6-BA, NAA or carbaryl.

1-aminocyclopropane carboxylic acid (ACC) - In one of two years, ACC demonstrated mild effectiveness as a thinner for Gala trees. ACC was most effective in 2022 when applied at 18.5 mm fruitlet diameter but had little effect when applied between 5- and 18.5-mm, and at 23.5 mm fruitlet diameter. Please note that apple cultivars may respond differently to the fruitlet thinner compounds used in this study. Furthermore, environmental conditions during and following metamitron and ACC applications at the various fruitlet stages used in this study are very likely influencing the thinning response

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Common Sense Planning for Climate Change Impacts on New England Orchards

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The Climate Adaptation Fellowship Program (CAF, www.adaptationfellows.net/) developed resources for New England tree fruit growers to conduct their own self-directed planning for climate change challenges and opportunities expected over the next few decades. This includes an overview of recently observed and projected weather changes in the Northeastern U.S., and a checklist of adaptation options. The checklist was created by four professional wholesale and retail apple growers from MA, ME, NH and VT, and an Extension IPM advisor. These resources are available online. Growers can use it to identify actions to make their operations less vulnerable to weather risks that occur now and that are expected to increase over the next 30 years, and to take advantage of new opportunities that a warming climate may bring. The curriculum is about adapting tree fruit orchards to changing weather, not the causes and political and economic responses to climate change at the global scale.

After introducing the self-directed checklist, the climate change review, and a curriculum guide, the remainder of the presentation will highlight some updated observations and projections for changes in growing conditions in New England for 2025 vs. the previous long-term normal, and for 2040-2069.

Even if greenhouse gas emissions are sharply curtailed in the next few years, because of lag in the climate system, continued changes in the weather over the next 30 years are almost certain. Tree fruit growers by the nature of their crop, are long-term planners. Because of climate change, the need for flexible and adaptive long-term planning to be successful in the already challenging tree fruit business has increased.

The four grower members of the team concurred that the frequency of spring frosts resulting in major apple crop loss has increased from what was roughly a 1-in-30 year event for their parents' or grandparents' generation to a multiple event per decade frequency. Team members agreed that the trends of warmer average temperatures, earlier spring warm up and bud break, more intense rain events, longer summer dry spells, and warmer autumns, have occurred with enough regularity to be seen as the new normal and not just random weather fluctuations. They also agreed that on-farm observations corroborate statements in scientific reports about measured trends in temperature and rainfall. And they agreed that weather at their locations has become more erratic over the past 10–20 years, with formerly unusual episodes of heat, cold, rain, and drought becoming more frequent or extreme.

The risks associated with climate change are more than simple trends in average weather. There is better understanding of how the climatic averages are changing than ability to forecast volatile weather extremes and their potential impacts on the food system. For example, rainfall totals can increase on average, but if precipitation variability also increases, then drought risk can also

increase. As the patterns and distribution of weather changes, unprecedented events become more likely.

There are no “one size fits all” solutions for the weather challenges listed. Instead of filtering out options that may be workable for only a few growers, the team decided that it would be better to include even marginally relevant options for adapting to a changing environment. Even if not applicable to most situations, those options may feasible for some growers, and for other growers may stimulate ideas for other possible responses.

The scope of the issues identified and adaptation solutions considered is limited to those that are directed toward continued tree fruit production. Thus, solutions such as “Stop growing tree fruit, switch to vegetables”, or “Get out of farming, sell your land for house lots” are not included.

There may be positive opportunities such as longer growing seasons that accrue from a changing climate, but in the process of creating this document, positive opportunities were overshadowed by the need to protect against negative impacts. The Tree Fruit Team decided that growers already know how to take advantage of positive opportunities, so there is less value in describing those potentials. However, the checklist does include a few positive potential impacts from projected changing weather in the Northeast.

Recognizing the reality and scope of global climate change is daunting. Effective response requires not getting overwhelmed. The climate adaptation curriculum is focused on maintaining a profitable tree fruit orchard, not changing the whole world. The issues highlighted here are based on reasonable expectations for conditions that will emerge over the next 30 years, possibly much sooner, and some that are already being noticed.

The checklist identifies 12 key climate change impacts, with suggestions of possible adaptation options, as shown in the Table of Contents.

The first checklist topic is shown below as an example.

1. High volume rain events.
Impact on Tree Fruit Production:
1a) Saturated soil in April - June limits tractor access, or results in deep ruts.
Potential Adaptations:

For new plantings:

___ Add drainage tile.
___ Water diversion paths.
___ Ditches w/ flash flood rip-rap.

For existing plantings:

Even if the ground is saturated, sometimes you have to go in anyway.
___ Use light tankloads.
___ Fatter or flotation tires may be an option for some tractors to reduce tire track damage.
___ Dual tire tractors.
___ Add drainage where possible.

Rut repair: (For when you have to get into the orchard despite damage to saturated soil).

___ Late summer rototilling of rutted areas, seed in with desirable alley vegetation, then stay off until next year. Thus you can only do alternate rows within the first year to retain access for harvest operations, and for the first spray trips of the next season.
___ An alternative option is filling in ruts with coarse sand or crushed rock/gravel.

Other tactics to reduce number of spray trips and rutting:

___ Monitor pest levels through foliar inspection, traps, and weather models to identify when pesticide application is needed, and when it can be avoided or delayed.
___ Alternate row sprays.
___ Use of apple scab fungicides with post-infection activity for more flexibility in spray timing.
___ Use trap-tree and perimeter-only insecticide sprays for plum curculio. This technique has been tested in research trials, but not fully validated in commercial use. It also, may not eliminate need for full block spray trips at Petal Fall and First Cover for full block application of thinner and growth regulators, foliar nutrients, and/or for full block protection against Plum curculio, European apple sawfly, European red mite, leafminers, leafhoppers, apple scab, or other insect and disease pests.
___ Trap out for apple maggot. However, this can be labor intensive and may not replace need for full block sprays for other reasons.
___ Border row sprays can replace full block sprays for apple maggot as long as there is no resident population inside. Therefore, intensive apple maggot monitoring is essential in this scenario.

___ Mating disruption for summer caterpillar pests (codling moth, obliquebanded leafroller, oriental fruit moth). But mating disruption is only viable for blocks with relatively low initial populations and for larger contiguous blocks (i.e. 5+ acres). Full block, every row coverage may still be needed for other insect and disease pests.
___ Where possible cutting back forest and other dense vegetation within 100+ feet of the orchard for air drainage and sunlight can also reduce pest pressure.
___ Airplane or helicopter spray application service is not currently available at a feasible cost in New England. The return of airplane application does not seem likely, but drone application is becoming available.

Fire Blight Management: Climate Change Considerations and Alternatives to Antibiotics

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Fire blight, caused by the bacterial pathogen *Erwinia amylovora*, is a serious disease of plants belonging to the Rosaceae family, such as apple and pear. Fire blight infection can occur on flowers and leaves, causing yield reduction, from there, it can further spread to the central leaders and rootstocks, leading to the death of the infected trees. Pathogen cells from the infected plant tissue can come out to the plant surface as bacterial ooze, which can be spread to the nearby uninfected trees, leading to large-scale disease epidemics. Annual losses to fire blight and control costs are estimated to be more than 100 million per year. Like many other plant diseases, climate change significantly impacts the occurrence and severity of fire blights. In this proceeding, we discuss the impact of climate change on fire blight, some successful non-antibiotic control strategies, and propose future directions regarding its management.

Impact of Climate change on fire blight disease management.
According to the plant disease triangle, a conducive environment is an essential prerequisite for plant disease to occur. Climate change, characterized by the elevated temperature, may affect fire blight mainly at two stages: blossom blight and overwinter. As the temperature is directly correlated with the growth rate of *E. amylovora* on flower stigma, temperature during bloom greatly impacts the blossom blight infection. However, apple-growing regions worldwide are differentially impacted by global warming. We summarized the average temperature in the month of apple bloom in 4 major apple-growing regions over the past two decades. Interestingly, some growing regions in North America and New Zealand, particularly in the Northeastern U.S., experienced a much more dramatic temperature elevation, as much as 2 degrees Celsius over the past 20 years. In contrast, Lake Constance Germany experienced a decrease in temperature during the month of apple bloom. For regions that experienced temperature elevation, fire blight risk is significantly higher as shown in the number of days with high and extremely high risk of fire blight, predicted by the Cougarblight model. Within the temperature elevation, fire blight has become endemic to some temperate regions that historically did not have fire blight, such as Maine and Vermont. The elevation of temperature in the Northeastern U.S. and increased disease risk are consistent with the actual disease severity observed in the field. According to a survey of extension educators and researchers conducted by the Northeastern Tree Fruit Working Group of the United States, the relative importance of fire blight in the Northeastern United States has increased over the past decade, and the ranking of importance has risen from the second most important disease to the most important disease of apple after 2014.

Climate change also affects pathogen survival/overwintering in cankers. Extreme weather conditions such as droughts are more frequently observed with prolonged periods impacted by climate change. Santander et al. (2022) reported that drought decreases the chances of detecting *E. amylovora* in cankers. Trees under drought conditions often developed shorter and heavier cankers as compared to irrigated trees. Furthermore, elevated temperature during winter months may improve the chance of survival of *E. amylovora*, as it was shown that the survival and

pathogenicity of *E. amylovora* is positively correlated with temperature (Santander and Biosca 2017).

Blossom Protect is the most effective and consistent biocontrol of fire blight.
Different biocontrol agents have been identified, tested, and commercialized in the past several decades. Most of them are bacteria such as *Pantoea agglomerans* (Bloomtime Biological), *Pantoea ananatis* (Llontop et al 2020), *Pseudomonas fluorescens* (BlightBan), *Bacillus amyloliquefaciens* (Serenade Optimum, Double Nickel), *Bacillus mycoides* (LifeGard), several bacteriophages (Gdanetz et al 2023), yeast *Aureobasidium pullulans* (Blossom Protect, Kunz et al 2023) and yeast *Papiliotrema terrestris* PT22AV (YSY). Based on multiple years of field data performed at different locations, *Aureobasidium pullulans* stands out from the rest as the most effective biocontrol agent that is commercially available.

Reasons why Blossom Protect is superior to other biocontrols
Stigma is the major site of epiphytic colonization, however *E. amylovora* invades through nectarthodes in the hypanthium. Most bacteria can colonize stigma but not hypanthium due to the high osmolarity caused by the high sugar content in nectar. Therefore, most current available biocontrol materials, particularly bacteria-based biocontrols, can only protect the stigma but not hypanthium. Yet field trials using these materials suggest that such a strategy cannot provide a consistent, high level of protection against fire blight. Yeasts generally are better colonizers of the sugary nectary than bacteria, with 10^4 to 10^6 CFU of *A. pullulans* recovered per flower after Blossom Protect treatment.

Most efforts of fire blight biocontrol identification focused on using biological control agents to suppress of pathogen growth through niche competition or antibiosis. However, many years of research suggest *E. amylovora* is extremely difficult to eliminate as it can better colonize the stigma surface than other commensal microbes. Zeng et al (2023) showed that *A. pullulans* in Blossom Protect strongly induces plant immunity in apple, which offsets the immune repression caused by *E. amylovora*, and suppresses fire blight infection effectively.

Integrating Blossom Protect with other non-antibiotic antimicrobials.
Some of the commercially available non-antibiotic antimicrobials provide some level of fire blight suppression. These products include Serenade Opti, Cueva, Oxidate. By themselves they cannot provide reliable, consistent protection against fire blight when disease pressure is high. However, when we combine the usage of these antimicrobials with Blossom Protect, they can further enhance the fire blight suppression of Blossom Protect. In this model, Blossom Protect is viewed as the foundational material, which should be applied twice before full bloom (once at 70% and again at 90%). The application of Blossom Protect induces plant defense and reduces susceptibility. The second component of this integrated management is the usage of an antimicrobial, Serenade Opti, Cueva, Oxidate, are all tested effective, and any one of these can be used. The selected materials should be applied during full bloom. If disease pressure is high, follow up with a second application at petal fall. This ensures if any *E. amylovora* cells remain on the flowers, they will be wiped out by the antimicrobial. This integrated management protocol has been tested effective in multiple locations over multiple seasons, in both research testing sites (CT, MI, VA, OR) and has been successfully adopted by commercial growers (OR, CT, NH, MI). It has become the standard control protocol for organic growers in the Pacific

Northwest. This protocol can also be an effective alternative for conventional growers who are concerned about strep-resistance presence in their orchard or as a rotation material with antibiotics.

Shoot blight management strategies in modern high-density apple orchards.
The plant growth inhibitor Prohexadione-calcium (ProCa) and plant defense activator acibenzolar-S-methyl (ASM) are the most useful materials for shoot blight management. Unlike blossom blight, the pathogen cells during shoot blight stage are located within the plant xylem, therefore cannot be easily targeted by surface-applied antimicrobials or antibiotics. Therefore, shoot blight management has to rely on the non-antibiotic category of materials. ProCa application to the early stage of shoot growth caused a significant increase in the widths of cell walls in cortical parenchyma cell layers normally infected by *E. amylovora* (McGrath et al. 2009). In addition to the increase in cortical parenchyma cell wall widths, ProCa has recently been shown to induce a resistance response in apple (Yuan et al. 2023). Similarly, ASM can induce a robust defense response in treated plants (Yuan et al. 2023). Applications of ProCa, or combinations of ASM and ProCa and spot treatments with larger dose rates of ASM have also been shown to effectively suppress the systemic spread of *E. amylovora* after infection. Thus, both ASM and ProCa are effective tools for shoot blight management and can be used either prophylactically or post-infection. A four weekly applications of Apogee (2 oz) + Actigard (1 oz) in tank mix, starting king bloom petal fall has been proven to be both effective against shoot blight but not significantly reduce shoot growth.

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Shifting Priorities and Challenges in Pome Fruit Pest Management

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'**Rogue waves**' are a constant presence in pome fruit pest management efforts which often create dramatic challenges with each passing season. These cycles often come in the form of fruit losses, caused by extreme fluctuations in weather patterns, and compounded by newly invasive insect and diseases, continued loss of pest management tools. Predicting unexpected events from a wide swath of climate and biological predictions is most challenging. Yet common sense, continued operational assessments, frequent field observations, employing predictive orchard modeling for insect and disease pest management, planning and conducting timely orchard upgrade implementation can be optimized for seasonal decision to improve resilience and long-term sustainability.

Shifting weather patterns causing extreme periods of drought, flood events, high winds, and temperature swings increasingly require orchard revisions. The “Long Island Express” Hurricane of September 21, 1938 may not reappear in our lifetime, yet the frequency of cyclical hurricane’s in the Northeast primarily peak during our harvest season. Sustained sudden high winds and rain continue to challenge tall spindle trellis support systems as tree architecture and support systems age and fail. Tree row growth exceeding the 9-10' wire height is enticing, as excellent quality fruit grows best in optimum sunlight. However, the significant costs of leader limb breakage, partial or whole row system collapse, outweigh short term gains. Sandy soils in wet locations, on hilly terrain with consistently higher wind often require stronger system support than flat orchard terrain with clay loam. Tree rows downed from recent heavy winds or 'microbursts' can be 'rescued' by removing the upper canopy above the 1st or 2nd scaffold, resetting tree roots if graft unions are sound and re-establishing in-line broken posts. Employing robust post trellis systems at planting and maintaining a 10' canopy is foundational for long term orchard production.

Weather pattern opportunities

- Extended drought provides ideal conditions to plan, expand, deepen and build new irrigation ponds and deep wells to provide irrigation during periods of drought,
- During flooding, critique water patterns and 'fall lines' throughout the orchard to develop diversion drainage, adding raised beds by shifting soil along the 'tire rut' tree line where water will pool, reducing tree row standing water.
- Invest in frost protection to mitigate freeze events.
- Follow weather patterns to optimize application windows of calcium carbonate sun screen prior to the heat event for sunburn prone varieties.
- Consider hail netting to protect highest value / most profitable varieties to reduce sunburn, reduce bird injury, locations of frequent hail causing significant loss of fruit volume and quality.

- Top-work unprofitable varieties to sustainable varieties such as to Aztec Fuji with increased color over 'dull' Fuji strains.
- Modify tree architecture upper canopy height, focusing crop load reduction 'thinning' in heavy cropping varieties such as Gala.
- Optimize timing and conditions for weed management such as 2-4D after first fall freeze followed by Spring management of Canada Thistle and Bindweed.

Structural support considerations: Trellis systems built to support higher density and higher yield need to withstand forces of wind, tree architecture, potential crop load, with proper span of wire and posts. Engineering to accommodate various soil types that will become saturated and act like a liquid .

- Resilient end posts anchors (6-8" or greater) of locust, Southern yellow pine, lodgepole or 'knot-free' pressure-treated wood spaced at 30', employing hydraulic or vibrating post driver. Depth of post requires 30% of the post height, no less than 4' into the ground with 12' trellis.
- High tensile, class 3, 12.5 gauge galvanized steel wire 2–2.5 ft apart.
- Shallow soils on bedrock require post restraints either above ground, at the ground level or below ground to increase strength. Nonuniform soils will have different depth requirements than more uniform soils. Additionally, netting will require additional support given increased wind forces. If growing fruit at 12' to 16', trellis accordingly.
- Support trees immediately after planting.

Tree decline: Seasonal variability of soil and air temperature play a significant role in rootstock cold hardiness. Early winter acclimation to cold temperature followed by fluctuations of both warming and freeze events or deacclimation can lead to the loss of hardiness during mid-late winter. M9 rootstock strains, such as M9-T337 and G16, appear to be more vulnerable to late winter freeze events. Rootstock freeze injury appears as lower trunk vertical bark splitting and bark cambium separation from lower trunk wood. The tree then responds in the production of ethyl alcohol (EtOH), highly attractive to ambrosia beetles. Since 2015, the species captured and identified in EtOH bottle traps across the Hudson Valley and those observed in trunk boring gallaries have been predominately the black stem borer (BSB), *Xylosandrus germanus*. Yet a newly invasive ambrosia beetle was recently found in NY's Lake Ontario region in 2024. Dissections of infested potted apple trees showing entry and exit holes made by *Anisandrus maiche* Stark (Coleoptera: Curculionidae: Scolytinae) in 'nesting' galleries. Unlike the BSB, injury to apple was noted in stems at the branch node in commercial orchards by *A. maiche*. The beetle is native to Asia, first reported for the first time in North America based on specimens from Pennsylvania, Ohio, and West Virginia. They attack only weakened or unhealthy trees, newly transplanted seedlings or healthy trees with wounds or broken branches. All species carry symbiotic ambrosia fungi that are usually benign to hosts in their native range.

Infestations of ambrosia beetles are most likely to occur in stressed trees attributed to winter injury, drought, flooding or weakened by the pest complex.

- Cultural control practices are the most common method for preventing ambrosia beetle infestations. These include removing and destroying infested trees, and eliminating the transport of potentially infested wood.

- Reducing tree stress is key by planting trees in well-drained areas
- Employing raised beds, providing proper irrigation, limiting southwest injury by painting trunks white, conducting yearly foliar and soil tests, maintaining low levels of weeds, protecting trunks and graft unions from herbicide and rodent damage to reduce injury to trunks.
- Provide early pyrethroid trunk applications to kill ambrosia beetle adults overwintering in trunks of infested blocks.

Scouting: The European gypsy moth (Spongy Moth), *Lymantria dispar dispar* (L.) (Lepidoptera: Erebidae), is one of the most serious forest pests in North America. It was accidentally introduced near Boston, MA in 1869, gradually expanding its North American range, currently established in 20 eastern and midwestern states. In 1910–1911, fungal entomopathogen, *Entomophaga maimaiga* Humber, Shimazu et Soper (Entomophthorales: Entomophthoraceae), observed causing epizootics in native gypsy moth populations in Japan was introduced in North American gypsy moth populations but *E. maimaiga* was never considered to have established. In the exceptionally rainy spring of 1989, *E. maimaiga* epizootics were found causing the collapses of outbreak populations in seven northeastern states (Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Vermont).

- After 29 years, outbreaks occurred in the northeast again. In 2024, *Lymantria dispar* emerged in late April with entry into orchards observed on 1st of May. Hypotheses are raised regarding how larval numbers increased despite the presence of pathogens and parasitoids.
- Recent data suggests that the fungal entomopathogen infecting Spongy Moth, *E. maimaiga,* requires cool, moist conditions during larval emergence. Whereas recent changes in climate have caused hot, dry conditions to the regional spongy moth habitat of the northeast.
- Mathematical models projected that climate change will sharply reduce *E. maimaiga* infection rates, greatly increasing spongy moth defoliation. Recent data show that defoliation has strongly rebounded, supporting projections.
- Effects of climate change on insect pathogens can have significant consequences for forests and demonstrates the importance of understanding how climate change can alter species interactions.
- Scouting orchards during early pre-bloom from Mid-April through May to observe the first presence and management of Spongy Moth.

Ahead of the curve: Scouting, Trapping and NEWA Predictive modeling. The management of the lepidopteran complex in some orchards begin at Pink with the observed emergence of the 3rd instar obliquebanded leafroller (OBLR). Management based on first signs of leafroller webbing should be made prior to bloom. Additionally, management against early emergence of Plum Curculio during Pink protects the earliest King fruit set through periods of extended bloom and prolonged pollinator activity. Codling moth (CM) emerge shortly after 1st cover, requiring CM tent traps and lures set along the orchard edge, hung near neighboring abandoned or homeowner orchards.

- Employing the most effective insecticide upon reaching the 250DD (base 50˚F BE) 1st hatch of Codling moth such as IRAC 28 (Verdepryn), followed by a second application at 10-24d of the same insecticide to maintain complete control of CM, significantly reducing the potential of a 2nd generation infestation.

- IRAC class rotation for the 2nd generation of Codling Moth management should employ the use of a different IRAC class such as Assail, which will also provide protection against Apple Maggot.

Use of Systemic Tools for Broad Spectrum Mid-Late Season Management. The presence of Wooly Apple Aphid (WAA) often requires management shortly after bloom, appearing on pruning cuts at green-tip in 2024. The difficulty in managing WAA often requires the use of a penetrant for the systemic materials such Movento on either side of Petal Fall and 1st cover due to plant growth regulators for crop load reduction and potential for over thinning, especially if a steep carbohydrate deficit occurs.

- An alternate approach would be the use of the neonicotinoid class to reduce WAA populations during the season when also managing Potato Leafhopper (PLH) in early June, Green Apple Aphid (GAA) Late June-July, and Apple Maggot (AM) (June-mid-August).

Make Cut Flowers Last: The Postharvest Info You Need

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Properly handled cut flowers last longer! And longer lasting cut flowers result in happy customers!

Many factors affect how long flowers will last, starting with preharvest factors, then harvesting, and finally postharvest handling. During these steps there are six main issues that must be considered at every step in the postharvest handling system: temperature, water, sanitation, carbohydrates, disease, and ethylene. Of these factors, temperature is generally the most critical, because it affects each of the other five factors. Nonetheless, all six can be limiting factors for various species and at various points in the marketing chain.

Preharvest. Optimizing the postharvest life of cut flowers begins with cultivar selection as they can vary greatly for each species. Other preharvest factors to consider include light levels, temperatures (especially night temperatures), nutrition, water status, and pests.

Harvest. Flower should be harvested at the best stage for the species, which can also vary with the market. For example, sunflowers for direct retail are harvested when the petals are at least perpendicular to the head (or fully open) as customers will be attracted to the petal color. However, sunflowers for wholesales will be harvested from when the petals are just beginning to lift off of the disc to perpendicular to the head as they will continue to open during marketing and there is less chance of damage during postharvest handling. Some flowers, such as gerbera, do not open up much or at all after harvest and should be harvested when they have just fully opened. Harvesting later will reduce vase life. Flowers that will be stored or shipped are cut at a younger stage than those being sold directly to the final consumer, especially those with large petals, such as glads and lilies, which might be damaged during transport.

Harvest Time. Flowers are typically harvested in the morning and placed in buckets of water or postharvest solutions. In the morning flowers will have their maximum water content and tissue temperatures are low. Flowers harvested in the afternoon will have the highest carbohydrate levels and are best for those flowers that will be stored for a while. Some species are very wilt prone and need to be harvested in the morning regardless of storage. Other harvest factors to consider include harvest method, foliage removal and bunching in the field, and transport from the field or greenhouse to the cooler or processing area.

Temperature. Temperature is the most critical factor. The warmer the temperature, the faster the respiration rate, the faster bacteria grow, and the more stems bend if they are stored horizontally. For every 10^{o}C increase in temperature, the respiration rate doubles and one day vase life is lost. Be sure to get field heat out ASAP.

Coolers should be set at 34 to 38^{o}F. While close to 32^{o}F is optimum for most species, 34-35^{o}F or 34-38^{o}F is more practical. A few crops, such as oriental lilies, zinnias, celosia, and tropicals are cold sensitive. Damage can be avoided by storing them in another location or cooling gradually, such as with lilies. The Take Home message for temperature: Short and cold as possible for species

Ethylene. Some species are sensitive to ethylene, which is a naturally occurring ripening hormone. Ethylene can cause leaf, flower and bud abscission; bud abortion, epinasty, which is a distinctive curling, drooping of leaves or bracts, and most damaging, rapid flower senescence. Steps to prevent ethylene damage include lowering the temperature, applying anti-ethylene agents, such as Ethylbloc (MCP) or AVG (STS), and removing sources of ethylene. A common question - Can cut flowers and veggies/fruit be stored together? Generally, no, but possibly, if duration is short and temperature is close to 32^{o}F

Sanitation. Good sanitation is needed to ensuring that flowers have a long vase life. Microbial growth in the bucket or vase water will block the stems. The golden rule – would you drink out of your buckets? While black buckets are often used for displays, it is easier to know when white buckets are properly cleaned. A number of cut flowers are considered to be high polluting in that they tend to make the water dirty by trapping debris on their stems and foliage or decompose fast. Such species include achillea, celosia, dahlia, gerbera, mums, sunflowers, and zinnias.

Air plugs. Air is drawn into stems when they are first cut and when they are held out of water for very long. These plugs are removed by recutting the stems. Eventually, however, the stems will start to deteriorate no matter how clean the water is or how often they are recut.

Water pH. For most species low water pH is best and tap water usually has too high of a pH. Flower foods have acidifiers that reduce the pH, even if your water has a very high pH.

Floral preservatives, flower foods. There are many products used during the postharvest handling of cut flowers. Most can be grouped into the following categories: hydrating, holding, vase, and species-specific products. They are available in a variety of formulations and sizes: powders, liquids, pills, buckets, jugs, packets, and tea bags. The majority of the products have the following components, **A**cidifier, **B**iocide and **C**arbohydrate, which can be remembered as "**ABC**". Flower foods are designed to fix critical issues such as wilt-prone flowers, bacteria control, ethylene sensitivity, leaf yellowing and other species-specific problems.

The number of options for flower foods can be overwhelming. One of the best strategies is to take a middle of the road approach and use a holding solution, which provides a low pH to boost water uptake, checks bacteria growth, provides at least some carbohydrates, and is active up to 5-6 days. Carbohydrates allow buds to open, develop and maintain petal color, and, of course, extends vase life.

Overall recommendations for using flower foods. High quality water (possibly with chlorine pills) should be used to hydrate flowers for at least four hours, and commercial hydration solutions should be used for species that need them. Commercial holding solutions (overnight or longer) should be used for most flowers, unless you see a problem, which is relatively unlikely.

Retail handling. Be aware that stored flowers may appear okay, but die shortly after sale. Thus, it is important to manage inventory and not allow flowers to be stored for too long. Be sure to provide flower food packets to customers, prevent physical damage by using sleeves or packing loosely in the buckets, and keep flowers in water or floral solution.

The Maine Tulip Experience

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Blossom and Bloom Festival started with a conversation; Wayne had with a co-worker about our farm. Co-worker asked "Your farm must be so beautiful with all those flowers?" and Wayne replied "well we never get to see them in bloom because we harvest them before they turn color." This sparked an idea in me. How can I afford to be able to enjoy hundreds of thousands of tulips in bloom for an entire season? How can I let other people experience this? I started with trying to research on my own about field grown tulips and agrotourism opportunities. I found very little concrete information. I reached out to every tulip grower in the US who was doing agrotourism, that I could find. A few people were able to get back to me.

Hubert Family Farms: Talking with Seth Hubert, the owner and mastermind behind their tulip fields in the red Alabama dirt, he shared the same ah ha moment as I did. Our farms were in a pickle of trying to figure out how to be profitable, enjoyable, and be able to offer something a little bit special to our community, that they wouldn't be able to easily find elsewhere.

- He stressed the importance of connections with growers and suppliers in Holland.
- Explained how there is no large-scale tulip farming equipment made in the US.
- The complexities of figuring out your bulb numbers and cost.
- Issues with growing in a different environment that isn't meant for tulips.
- Trial and errors with planting and overall crop success.
- Stressed the importance of charging admission and early ticket sales.
- Stressed the importance of marketing.
- Complexities around predicting dates during the variable spring changes.
- Shared different bulb suppliers he has worked with.
- All tulip bulbs come from holland.
- Trial and error of finding what varieties work for his land, as well as crop rotations to manage disease.
- I need to talk to Emily from Wooden Shoe Tulip Farm in Oregon.
- How he reached out to a lot of growers in the US as well and some were not as welcoming. I shared I had the same experience. But we both understood why; they are afraid that niche they have found in tulips and the increase in flower farming will no longer exist if to many people start doing the same thing.

Dalton Family Farms: I talked with the current owner of Dalton Family Farm in New Jersey; he expressed again a lot of similar thoughts and process of how they came to the decision on growing tulips for agrotourism. He expressed a lot of the same things as Seth but a few different ones are.

-Importance of selling tickets, charging per a stem, and pre-sales.
-Having the proper equipment is vital in making numbers work but finding it could be more challenging.
-Finding the right method planting method for your soil.

I was able to plan a trip out west during their Tulip season which happens a few weeks earlier than ours in Maine. I visited several tulip farms from Oregon up through Skagit Valley in Washington and talked with several growers. This was the most crucial education piece for me in seeing how things are done. Many of these farms have existed for several generations growing tulips for bulbs, cut-flowers, and now almost all of them solely make their money through their yearly tulip festivals. They all also have some direct connection to Holland, have holland farm equipment, and have trialed several different methods.

Wooden Shoe Farm in Oregon: I spoke with and still occasionally reach out to Emily who is now the next generation taking over the farm from her mother's generation. I was able to take a tour of the farm during their festival and see their processing equipment as well as warehouses. Both Emily and her mom opened up to me and answered all of my questions and gave some great advice.

- Pre-sale tickets.
- We will always have to buy bulbs.
- Farm equipment from holland.
- Bloom time unpredictability and how to manage that.
- Crop rotation importance, bulb harvesting equipment.
- Might be able to save some bulbs but it will take some time to figure out what will be worth it depending on our farm and environment.

Our first year of growing field tulips for u-pick/agrotourism: Ordered just over 100,000 bulbs. They came in a tractor trailer on pallets stacked with crates 10 high.
-I ordered the All Season Barn mix as well as a few specialty tulips for cut-flower production. From ADR bulbs.
-We planted them all by hand in late October, using a walk behind troy built tiller, hoe, rake, and a shovel.
- Used the troy built to till up the land and a potato hiller attachment to create furrows.
- Took a crate of bulbs at a time and just dumped them into the furrows.
-Covered them up with rake, hoe and shovel, burying them about 4-6in deep.
- Field covered an entire acre, two trenches per a row about a foot wide each with 3ft walking path in between.
-Had lots of rain and snow so no irrigation was needed.
-Started with pre-sales online for a season pass; which allowed people to come whenever they wanted.
-We did a lot of advertising on social media, radio advertisement and I passed out a lot of fliers. (During the season we were featured in Maine Business magazine and Portland Press Herald.)
-social media and word of mouth seemed to be the most successful.

-When I officially announced we had opened for the season we quickly saw our ticket sales increase. I implemented a parking pass (free) but allowed us to make sure we had enough room and did timed ticketing. (Important on regulating flow of people)
-We sold out every weekend day we were open.

Here is a general summary of financial numbers:

Tulips 2023 Costs		
bulbs	30,000	100,000
merch	3344	
workers	1450	
total	$34,794	

Tulips 2023 Profit	
stem sales	1878
ticket sales	15187.07
Festival sales	2907
u-pick tulips	16575
total	$36547.07

*Although on paper it looks like we just barely broke even we did not include our own labor in the costs. *

The biggest lesson learned is the need for and the value of mechanization. Some smaller take a ways; better planning of actual event surrounding the bloom, parking considerations, variety changes, having more days open, more people for checking people out with their u-pick, and having a field person to help manage people in the field during u-pick.

Basic Production Considerations:

With the lack of research on field grown tulips in the US and specifically, New England, a lot of trail and errors will have to continue to figure out how to make tulips work for our farm ecosystem. Some major cultural practices to take into consideration are how many bulbs to plant, daffodils and tulips, crop rotations, pest and disease management, and post-harvest handling.

I have adjusted how we are planting bulbs to hopefully better cover the same amount area without as many bulbs and still give the same impression. By spacing tulips out just a bit more and adding some field props to take up some space. Tulips can be planted essentially right on top of each other. They have roots that allow them to shift themselves and move in a good position to grow how they desire. This means, it is not necessary to carefully orient the bulbs just throwing them in the ground and allowing them to be a bit more space apart will be more efficient.

Adding other ornamental geophytes to extend the blossom and bloom season, create more diversity in the field, and hopefully mitigate some tulip specific pest and diseases such as: several soil borne fungi like Fusarium and Rhizoctonia, other fungi such as Botrytis (tulip fire), nematode vectors for Augusta disease, aphid vectors Tulip Breaking Virus, and the most dire pest for this region deer. (Kamenetsky & Okubo, 2013) When it comes to management I think about these diseases as they are handled for a variety of other plants that we already have a lot of research on. Relating them to things we already know and making changes I come across on them. Most tulip growers of this scale in the US, who are growing for u-pick, are not saving

bulbs and replanting every year. This itself mitigates a lot of disease pressure. The second best is having a good crop rotation. The hard rule is 7 years but with good management and good rotations I think you could bring this down to three or four years. After your first season you'll want to make sure you get all of the plant material out of the ground, heavily supply the ground with organic matter (manure) and then plant in a cover crop. The goal is to let the soil rest and to rebuild the health and structure. There was research that had been started in 2015 at Washington State University on cover crop rotation in tulip fields to manage diseases. Unfortunately, I can't find it completed and when I reached out to the Professor, he had retired. There is a lot of assumptions about controlling these diseases the same way we control similar diseases through cover cropping and rotation could be very beneficial. Prospective of mustard, legume, and some kind of mix, rotation through the years. We are in the early stages of experimenting with different methods on a very small scale at the moment. We do know that cover cropping rotation around 7 years works for a lot of growers in the US, without the need to use pesticides or fumigation. During the season once tulips have bloomed it is important to "top" them, think about cutting garlic scapes, very similar idea. Not only is this forcing the energy back to the bulb but it also allows you to check your field for disease and pull any suspect tulips out. If you are just continually buying new tulips the effort to top them is probably not worth it.

Post-harvest: the most important thing is getting all the plant material out of the ground. We do not own a fancy planting system. Hand pulling digging, tilling in what's left and then manure, cover crop and not touching that field for a few years is the goal, until we can invest in the net system. Which plant the bulbs into a net so when the season is over you just pull the entire net up.

We are very low scale experimenting with saving bulbs. One thing I was told from Wooden Shoe is that you have to be vigilant at experimenting because a lot of tulips will not naturalize. Bulb growers have been selecting tulips for their one-year wow factor, disease control, and not for the ability to naturalize. Tulips are very picky about the conditions they need to be perennialized and those conditions that need to be met are similar to where tulips originate from, which is the Himalayas. Tulips are most happy in continental thermoperiodic zones, like Syria. (Kamenetsky & Okubo, 2013) Tulips above ground growth, last 3-5months in these regions. They replace storage unit every year. (Kamenetsky & Okubo, 2013)I estimate in Maine their above ground growth is maybe 2 months in a really good season. It's my understanding and assumption that due to our climate not being ideal to give tulips that extended growing time they would really need in order to store enough energy to produce a quality new storage organ and no longer putting an emphasis on breeding for landscaping, that this is why we do not have reliable perennial tulips.

Hopes for the future: The toss-up between too many tulip farms and not enough tulip farms to validate doing research on them, in our environment, is a tricky line. I believe there is a lot of potential for further research into field grown tulips for Agri-tourism and cut-flowers, in the New England Region. My favorite thing about farming is the potential and necessity to always be learning something new. With all the farmers and bulb suppliers I have talked to it seems that they are constantly trialing different techniques to figure out what works. Maybe the most important thing Emily's mom said to me was to never stop evolving. Continue the evolution of your farm with the rest of the world around you and yourself.

Bibliography

Kamenetsky, R., & Okubo, H. (2013). Ornamental Geophytes. In R. Kamenestky, & H. Okubo, *Ornamental Geophytes* (pp. 363-370). Boca Raton: CRC Press.

The Latest and Greatest New Cuts

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Sources of Inspiration

- Association of Specialty Flower Growers (ASCFG) National Trials
- Breeders and suppliers
- Travels and growers

ASCFG Cut Flower Trials Highlights

- *Centaurea moschata* 'The Bride' (Takii Europe/Sahin)
- Centranthus 'Roseus' (Ball Seed)
- Cosmos 'Kirro' (Takii Europe/Sahin)
- Lobelia experimental series (Syngenta Flowers/Floranova)
- Ornamental sorghum Prairie Pearls series (InFlora/Express)
- Sunflower 'ProCut Yellow Lite' (NuFlowers)
- Fresh/Dried Flowers
    - *Ammobium grandiflorum* (Takii Europe/Sahin)
    - Rhodanthe 'Goliath' (Ball Seed)
    - Helichrysum King Size Mix (InFlora/Express)
- New lisianthus (American Takii, Ball Seed, InFlora/Express)
- New marigolds (Homeseeds)

Flower Farms and Trials Highlights

- Caryopteris 'Pagoda Lagoon' and 'Pagoda Blush' (Danziger)
- Caryopteris 'Emerald Crest' and 'Gold Crest' (Darwin Perennials)
- Caryopteris 'Grand Bleu' (many sources)
- Japanese anemone (many sources)
- Sunflower 'Sunfinity Yellow' and 'Double Yellow' (Syngenta)
- Sunflower 'Suncredible Saturn' and 'Yellow' (Proven Winners)
- Zinnia 'Agave', 'Aurora' and 'Ballerina' (Johnny's Selected Seeds)

Cut Foliages

- *Eucalyptus polyamthemos* (Ball Seed)
- *Eucalyptus gunni* 'Silver Drop' (many sources)
- *Eucalyptus pulverulenta* 'Baby Blue' (many sources)
- *Eucalyptus lunata* 'Moon Lagoon' (many sources)
- *Eucalyptus neglecta* 'Big O', *E. parvula* 'Funky Monkey' and *E. nicholii* 'Angus' (Southern Eucs)
- Carthamus (many sources)

- *Clematis paniculata* Sweet Autumn (many sources)
- *Hibiscus acetosella* ‘Mahogany Splendor’ (many sources)
- *Passiflora caerulea* (many sources)
- *Salvia officinalis* ‘Silver Scent’ (Darwin)
- *Sambucus nigra* ‘Black Lace’ (many sources)
- *Solidago sempervirens* (many sources)

Cut Flower Production in A High Tunnel

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Growing in a High Tunnel offers a controlled environment compared to exposed field grown crops. It's a more favorable growing condition, while also bringing unique challenges. Understanding how to best utilize and maintain your CEA (Controlled Environmental Agriculture) structure can elevate your business and produce more valuable crops.

The values I will discuss include Season Extension, Protection from Elements, Irrigation Regulation, Soil Fertility, Seed Saving, and Integrative Pest Management.

A tunnel is any sized hoop unheated structure covered in a single layer of greenhouse plastic. Most have roll up sides and vents, some may have built end walls, or open ends to allow equipment to enter. Low Tunnels are mobile, smaller and can span 1-4 rows, where High Tunnels are larger and more permanent.

Season Extension.
My farm is now Zone 6a. I utilize High Tunnel blooms from early April - early November, while my field crop blooms range from June through September. Spring blooms are planted in the Fall, overwintered with the use of row cover for warmth, and Summer and Fall blooms can be planted in early to Late Spring, with the addition of shade cloth to keep it cool.

Fall Plantings I include, as transplants, are Ranunculus, Anemone, Icelandic Poppy, Snapdragon, Foxglove, Delphinium, Feverfew, Campanula, Sweet William, and as Direct Seeds, Larkspur, Burpleurum, Delphinium, Phacelia, Calendula, Tulips. It's best to pair the similar timed harvests in same rows, and/or if the crop allows you to succession plant for extended harvesting, as these varieties aren't favorable when it becomes warm, and you will want to "flip" the bed immediately for next round of plantings. However, shade cloth has extend the Early Sping blooms up to 3 weeks, while also providing longer stems making the flowers "reach" for the Sun.

Early Spring Plantings I include are Feverfew, Snapdragon, Lisianthus, Dusty Miller, Delphinium, Calendula, Sunflowers.

Late Spring Plantings I include are Dahlia, Mums, Sunflowers, Statice, Lisianthus.

Varieties I perennialize through root stock or self-seeding include Eucalyptus, Dusty Miller, Delphinium, Snapdragon, Calendula, Celosia, Ageratum.

It should be noted that diligence in temperature regulation during Late Winter & Early Spring is crucial in not baking your tender transplants. Row cover is necessary at night to protect against cold temperatures, but if the sun comes out during the day, and the sides are down, the

temperature inside can quickly reach 100 degrees F. It can become a morning and nightly chore to roll the sides up and down and apply row cover on and off.

Protection from Elements.
Most varieties appreciate growing under a tunnel, although crops especially sensitive to rain and wind include in Spring, Delphinium, Foxglove, Poppy, Ranunculus, Anemone; in Summer Statice, Lisianthus, and in Fall Dahlias, Mums. Other varieties that grow from corms and bulbs prefer Tunnels so they don't become overwatered and prone to rot. All varieties of any root form are less prone to root rot because you can manage the irrigation.

Wind is also a major consideration in most fields, requiring strong staking and trellising. The High Tunnel allows you better control of space to manage the plants and straight stems.

Ornamentals thrive in conditions where the Foliage and Blooms are dry and the irrigation is only delivered through roots. Not only aesthetically reasoned, the less water on the foliage, the less disease of fungal and disease spread.

Irrigation Management. In addition, the control of irrigation can be more effective to stronger root systems and water retention methods. Pulse watering is a common practice that is less quantity more often, and is shown to retain moisture longer.

Another important consideration is to know pH of your water. Ideally the plastic is replaced every few years and a gap year of leaving plastic off for a season can help air out space and also bring pH down through use of rainwater.

Soil Fertility.
Soil can change rapidly in a tunnel. Soil tests should be done regularly, especially in the cases of crops with specific nutrient and pH needs. Keeping records each year is a helpful resource, especially noting phosphorus and calcium levels, and trying not to add composts that have too much high phosphorous levels as too much can build up in the soil and lead to poor growth. Monitoring the pH of the soil and water is helpful in understanding the nutrient availability, ideally they are between 5.5 and 6.5. High tunnels usually have a higher pH because of the addition of composts throughout the years. Adding elemental sulfur can help bring pH down, and as previously noted, leaving plastic off for a season can also help bring pH down.

Seed Saving. A contained environment will allow flowers to dry out and seeds ready to be harvested as they mature. You can also utlilize tunnel spaces to isolate certain varieties to not be cross pollinated.

IPM.
The longer the growing period, the more prolonged pest management is. Regular scouting is encouraged and familiarity of common pests is crucial in rapid eradication. Knowing which crops are prone to which pests and disease is very helpful in prevention. Common pests include aphid, whitefly, mites, hornworms, various beetles, slugs, loopers, thrips, tarnish plant bug; and diseases include powdery mildew, blight, and wilt.

Management of these issues can be handled through Cultural, Mechanical/Physical, Biological, and Chemical ways.

Cultural practices include sanitation/maintaining clean space, weed management with use of plastic mulch, drip tape irrigation, quick crop turnover, crop diversity, and utilizing vertical space and trellis to not overcrowd, and tarping certain rows between seasons.

Mechanical/Physical practices include strong scouting skills, and manually taking out noticeably damaged plants and pests, encouraging ventilation and air flow, keeping cold temperatures during evening, use of shade cloth to not let space become too hot and humid. Also, the use of traps and sticky cards can help identify what is present.

Biological practices include appropriate cover cropping, release of bio-agents, and predatory insects.

Chemical methods prescribed targeted sprays on localized outbreaks. It's important to follow instructions and take note of the effectiveness of what is used. If it isn't effective, omittance of a specific crop may be a better option for the health of whole tunnel.

In conclusion, growing in a tunnel is absolutely my favorite setting, and I hope to continue to build more in my operation, and refine the methods to best utilize them and push the seams on what's possible year-round.

Tractor Scale No-Till

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Moulton Farm is located in the heart of the Lakes Region at the north end of Lake Winnipesaukee. We are retail based with a 2500 square foot farm market which also includes a commercial kitchen and bakery. In addition to the food we grow and make, we partner with other New England farms and small businesses to provide people with quality fruits, cheeses, seafood, meats, and poultry. We have approximately 40 acres of farm land on site, and farm an additional 35 acres of land at other offsite locations.

In 2020 we were approached with the suggestion of trying to grow no till sweet corn on a 2-acre parcel of land that has a fairly steep slope. We had been traditionally working this field for at least 10 years and even though we were good about getting a cover crop seeded every fall we still struggled with field erosion and washouts. In the winter months of 2020, we came up with a plan to modify our corn planter so that it would be able to plant through the northeast veggie mix cover crop that we had seeded in the fall. We have a Monosem NG plus 2 row vacuum seeder that we plant all our beans, peas, and sweet corn with. The modifications we made to the planter were fairly simple, completely adjustable, and easily taken on and off which was important because the majority of the planting we do is still traditional.

Our planter was already equipped with a standard face plate in front of the seed unit, so we purchased a set of fixed position residue managers which is the least expensive way to go. The height of the residue managers can be adjusted with a pin, but they do not float at all or move with the terrain like some of the more expensive units do. We also purchased a set of spiked closing wheels, which do a better job than the smooth wheels in rougher terrain, and a set of drag chains to ensure seed coverage. When using the planter for no-till seeding we also adjust the pressure springs on each seed unit to approximately 350lbs, which is considerably higher than the 100lb setting we use for traditional planting. This helps to make sure the V disc openers are cutting a good trench for the seed to fall into in the hard/ untilled ground.

In the spring of 2021, we applied an herbicide over the cover crop mix in preparation for our first ever no-till seeding. Prior to planting we spread 500lbs/acre of 15-5-20 on the field. We spread again once more when the corn was approximately 10 inches tall at the same rate. The planting went well; however, we did find out how important it is to have the field well prepared before seeding the cover crop. Our field was left rough and ragged with a lot of uneven terrain before I had seeded the cover crop in the fall. This caused issues with seed coverage in the spring planting. We found ourselves constantly adjusting the planter to try and get better coverage but found that no matter what we did it would not cover the seed in the roughest parts of the field.

After harvesting what we considered to be a decent first crop of no-till sweet corn, we decided to address the roughness of the field and start over by traditionally plowing and harrowing it before seeding it with cover crop. That was the last time we have turned the soil in that field and our no

till plantings have been going great ever since. One of our biggest concerns before starting the no-till plantings was how to go about getting the cover crop on in the fall. Fortunately, the Belknap County Conservation District owns a beautiful no-till seed drill that they will rent. So, every fall after our corn is mulched, we make arrangements to rent the drill for a couple of days and seed our cover crop on all of our no till fields.

We have definitely noticed an improvement in the erosion and washout issues we were having since we switched to no-till. We have gradually been planting a little more no-till sweet corn each year. The summer of 2024 we planted 6 acres within 4 separate plantings. That is a small amount of the sweet corn we grow, but slowly transitioning to more no-till sweet corn plantings is saving time and labor on the land preparation aspect of traditional planting, and it is helping to create healthier soils by reducing erosion, and increasing organic matter.

Residue manager

Spiked cover wheels and chain drag

No-till planted set

No-till seed drill for cover crops

What's Happening in the UNH Breeding Program

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The UNH Cucurbit Breeding Program has contributed to the development of countless new squash/pumpkin varieties over the years. The program has been ongoing since the 1950s, and is considered one of the longest running public sector squash and pumpkin breeding programs in North America. Work in winter squash focuses on the eating quality and yield of acorn, butternut, and kobocha type squash. The program also works extensively with ornamental pumpkins. Breeding for increased disease and pest resistance is a priority across all market classes. Recent funding from NEVBGA along with funding from the New Hampshire Specialty Crop Block Grant Program has been used to explore color and color retention in commercial and experimental pumpkin hybrids.

Ornamental pumpkins, Jack O' Lanterns, are popular in New England's agritourism industry and are therefore an important breeding segment for the UNH breeding program. Current trends in ornamental pumpkins point to increased interest in different rind colors. In particular, demand is rising for green or "black" pumpkins and white pumpkins. Unfortunately, both black and white pumpkins suffer from color change before and after harvest due to natural aging and exposure to sunlight. Seed catalogs typically recommend harvesting white varieties slightly under-ripe and storing fruit in a shaded area; however, this is not always practical. Trials were conducted in 2023 and 2024 with two main objectives: 1.) determine whether there is meaningful variation in commercially available hybrids for color retention (staying white or green) and 2.) evaluate UNH breeding lines and new hybrids for their color and color retention. Preliminary results for commercial hybrids are shown below in **Table 1.**

Hybrid	2023 Trial	2024 Trial
Blanco	NA	1
Casperita	1	1
Snowball	NA	1
Moon Beam	1.5	1.67
Abominable	NA	2
Snowdrop	1	2
Icicle	1	2.33
White Lightning	NA	2.33
Honey Moon	2	2.67
Moonshine	2.25	2.67

Table 1: *Results for commercial hybrids for white color retention across trials in 2023 and 2024. Hybrids were harvested and left in sun from roughly two weeks before rating. A score of 1 corresponds to very little yellowing whereas a score of 4 corresponds to yellowing of entire fruit.*

The varieties Casperita and Moon Beam performed well across trials. Blanco and Snowball were only grown in 2024, but also showed excellent color retention. Icicle and Snowdrop were

inconsistent—both showed excellent color retention in 2023, but performed much worse in the 2024 trial.

The black/green pumpkin Dark Night was grown in 2023 and 2024, and displayed significant orange coloration in both years. This same problem was also observed for Midnight, which was only grown in 2024. These results suggest that the same precautions that are taken for white varieties, limiting sun exposure and harvesting earlier, should be taken for black pumpkins as well.

Spraying Strawberries: Maximize Coverage, Minimize Risk

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As stated on the pesticide label – the sprayer needs to be calibrated before you spray!

Each season, strawberry growers may apply spray materials worth $100's or more an acre when using sprayers. Many of the materials applied can potentially protect the crops and plants from pests, supply nutrition, or regulate plant growth. However, the failure to apply a spray evenly to its target can cost growers much more than the original price of the material and the $35/acre application costs. Poor spray coverage is the primary cause of reduced spray product performance. Growers must often adjust sprayer outputs and vary application speeds throughout the growing season to account for variations in crop structure, the time of season and the purpose of the spray. Unfortunately, some growers often bypass these adjustments because sprayer calibration is considered difficult and time consuming. Sprayer calibration adjustments are worth the time and effort.

Growers need to evaluate these questions and their answers when spraying their strawberry crop.

- What is your TARGET?
- What sprayer are you using?
- What type of spray tip nozzle and size orifice are you using?
- What speed are you travelling at?
- What pressure are you using?
- Is drift a potential problem?
- What is the distance between the spray tip and target zone of the plant?

The applications of various spray products are important. Problems with inadequate spray products' efficacy and phytotoxicity are often due to sprayer design for strawberry plants, inaccurate sprayer's calibration, and pesticide dosage. Off-target spray drift has a measurable economic impact, including the loss of chemicals that should have been applied to the crop, and potential damage to adjoining crops and property. Off-target spray drift may also contaminate surface, ground water supplies, and pose health risks to animals and people. Additionally, rising legal liability costs have made added attention to properly calibrated and operated spraying equipment vital for operations of all sizes.

There are multiple basic sprayer types used in spraying strawberries, and each have their strengths and weaknesses:

- Boom Sprayer (horizontal)
- Air Blast Sprayer
- Air Shear Sprayer
- Boom Sprayer with Air-Assist
- Backpack Sprayer
- Backpack Mist Sprayer (air shear sprayer)

Nozzle type and nozzle orifice size are important, but many forget nozzle orientation, nozzle spray direction, and distance from nozzle tip to target.
Chemicals must be applied at the correct rate. Too little will reduce the effectiveness, and money will have been wasted on the material and its application. Pest injury may also result. Small fruit growers forget how a mis-calibrated sprayer could cause phytotoxic damage to the crop and/or the bushes. This can affect a farm's profitability, and proper calibration and spray deposition can prevent it.

Actual application rates in the field may vary from nozzle catalog values because of pressure gauge error, wheel slip, speedometer error and friction loss in the plumbing. A catalog is satisfactory for selecting the correct nozzles, but the sprayer must be checked under actual operating conditions to adjust the pressure and/or speed for the required application rate. In addition, on some machines, the spray pattern on the left side of the sprayer is different from that on the right. This is difficult to detect without special apparatus.

Spray Deposition or Spray Coverage
Before checking the spray coverage pattern, check your sprayer and all its components. Make sure that it is set up correctly, the pressure is correct; the nozzles are at the correct height for the crop being treated, the distances between the nozzles are correct, and that the nozzles are not plugged. Evaluate the sprayer at the same speed (RPM, gear, and throttle setting) you plan to use when treating your intended crop or area. Put clean water in the tank when testing.

Water Sensitive Cards can be used to verify spray coverage. These one-use cards are available from some pesticide suppliers and spray equipment dealers. They are yellow and turn blue when a drop of water or oil touches them.

To evaluate, set up a series of cards on the crop you intend to spray. Clothespins can be used to clip cards to plants. For a highbush blueberry planting, set cards at the top of the canopy, and in the interior, both in the middle and lower in the canopy. Mark the position on each card with a pen. Run the sprayer once by the row or block. Retrieve the cards. The blue dots will show your sprayer's coverage. If necessary, you can replace the used cards with new cards, adjust your sprayer settings, and perform a second test.

The air blast sprayer's nozzle orientation affects the spray pattern that is emitted. With an air blast sprayer, nozzles are positioned radially around the sprayer's air outlet. On a counterclockwise fan rotation, the air blast carries the droplets upwards over the canopy on the right-hand side of the sprayer, and downwards on the left-hand side.

To evaluate spray coverage with a boom sprayer, visualize the pattern by spraying on a dry farm roadway (dirt or paved) or a long, flat patch of concrete. If gaps or heavy patches show up, make adjustments to correct the spray coverage. It is difficult to quantify differences using this method, but it is quick and simple. You can also use the water sensitive card as described above.

By evaluating and calibrating the sprayer, the rate sprayed per acre and spray coverage can be confirmed. There are several changes that sprayer operators can make to modify their sprayer to maximize application efficiency:

- Operation speed.
- Spray pressure setting.
- Type of spray tip nozzle to be used (you can have different spray tips on the manifold).
- The spray tip orifice size (you can have different spray tip orifice sizes on the manifold).
- Location of different spray tip orifice sizes or types of spray tips on the manifold.
- Direction of spray tip nozzle bodies and tips.
- With some sprayers, you can alter the fan speed or fan angle to adjust air flow.
- Use an air deflector to direct air flow.
- Turn off some spray tip nozzles.

Final thoughts to take home:

- When spraying - change direction of sprayer coverage. If you spray down the row, the next spray application should go in the opposite direction so you will have a different spray shadow.
- Do not start spraying a block in the same row or end on the same row.
- Double check your speed and pressure.
- Clean filters every time the sprayer is filled.
- The skills of the person who will operate the sprayer should be considered.
- Clogged Nozzle - Can of Air!

University of New Hampshire Extension YouTube website for sprayer calibration videos:
https://www.youtube.com/playlist?list=PLoiAXcxNjJLPTgzxe5gP3D4M8MQFd4JFw

University of New Hampshire Extension website for sprayer calibration article, calibration worksheets and videos:
https://extension.unh.edu/blog/2024/01/pesticide-sprayer-calibration-use-care

Cyclamen mite management in strawberry with transplant steam treatment and miticides

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Cyclamen mite (*Phytonemus pallidus*) is often a serious pest of cultivated strawberry. All life stages (adults, nymphs, eggs) are found in strawberry crowns, developing fruit buds and new, folded leaves. Cyclamen mite feeding causes leaf curling, leaf discoloration, shortened petioles leading to plants that appear small and stunted. Feeding on fruit buds results in fruit that does not size and ripen and is not harvestable. Losses of up to 50% have been reported when cyclamen mite populations are not controlled. Management of cyclamen mite primarily relies on miticide applications; however, since few products are registered, additional tools for control are needed.

Transplant steam treatment Since cyclamen mite can be found on strawberry transplants, preplant steam treatment may be an effective control method. Diseases, such as anthracnose, botrytis and leaf spot, have been controlled on transplants using steam treatment 44 °C/111 °F for 4h. In field experiments with bareroot, short-day strawberry cultivars infested with cyclamen mite from a laboratory colony, 44 °C/111 °F for as little as 1h eliminated >99% of cyclamen mite, and populations were less than 5 mites per trifoliate at 13 months after planting. Steam treatment at 44 °C/111 °F for 1h had no negative effects on 'Jewel' survival, growth, runnering or yield, but for 4h negatively affected survival of small crowned (6-8 mm or ¼-⅓ inch) transplants but not larger (11-13 mm or ⅖-½ inch) crowned transplants. In a follow-up experiment, there were no negative effects of steam treatment at 44 °C/111 °F for 2h on bare-root 'Annapolis', 'Audrey', 'Evelyn', 'Jewel', 'Kent', 'Laurel', 'Lila', 'Mira', 'Valley Sunset', or 'Wendy', but survival was below 90% for 'St Laurent' and yield was lower for 'Cabot' than the unsteamed control.

In day-neutral strawberry, there was no negative effect of steam treatment at 44 °C/111 °F for 4h on frigo 'Albion' transplant survival, and 97% of cyclamen mite were eliminated. Steam treated 'Albion' plants had smaller leaves than untreated plants, and yield was delayed; however, the total yield was not different between steam treated and untreated plants. 'Albion' transplants planted in the spring for runner production were also not negatively affected by steam treatment at 44 °C/111 °F for 2h or 4h; steam treated plants produced slightly more runners than untreated plants.

Transplants were steam treated for research purposes in a converted growth chamber (~$1.1m^3$ = 1.4 $yards^3$) using an Amerec steam generator and copper piping with small holes on the floor of the chamber from which steam emitted. Larger, commercial steam units for plants are available from Plantsauna (Moleda). All 44 °C/111 °F steam treatments were preceded by a 1h pretreatment at 37 °C/ 99 °F.

Miticides Agri-Mek® SC (abamectin) is often relied on to control cyclamen mite in strawberry, but recently Magister® SC (fenazaquin) was registered for mites in strawberry in the United States and Canada. In all greenhouse and field experiment, application of Magister® SC at the

highest label rate resulted in cyclamen mite numbers equal to or less than those when Agri-Mek® SC was applied. In the field, 1 application of Magister® SC about 1 week after renovation resulted in improved yield and fewer cyclamen mite damaged strawberries the following year compared to the untreated control. Other miticides registered in strawberry were tested as well, and Nexter® SC (pyridaben) resulted in low cyclamen mite numbers after greenhouse and field applications, whereas Oberon™ Flowable (spiromesifen) was moderately effective in the greenhouse but more effective in the field. A number of biopesticides were tested as foliar applications or transplant dips, but most products resulted in no control of cyclamen mite. The only exception was foliar application of Venerate CG® (*Burkholderia* spp. strain A396) which resulted in a small cyclamen mite population reduction in the field.

In conclusion, using steam treatment at 44 °C/111 °F for as little as 1h will eliminate most cyclamen mite on transplants without compromising growth or yield in spring plantings of short-day or day-neutral strawberry cultivars. Currently, it is not uncommon to apply miticides for cyclamen mite in the planting year, but steam treating strawberry transplants should eliminate such a need. If miticide applications are needed in the second or third year, particularly in matted-row systems, Magister® SC is an effective alternative to Agri-Mek® SC. All miticide applications should be made at high water volumes (up to 1000L/ha or 100 gallons/acre), at low tractor speeds, and with a non-ionic surfactant so that the miticide reaches the cyclamen mite in the new, folded leaves and in crowns.

Virtual Tour of Wards Berry Farm

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As I looked through photos of our strawberry plantings over the last 5 years…I'm noticing how much our production methods have changed/evolved over the 40 years since we started growing them.

- We improved irrigation and frost protection using 15 mil drip tape and meganet sprinklers for frost protection
- Battling weeds using biodegradable mulch during the establishment year. Eliminated pre-emergent herbicide use to reduce crop injury
- Planting plug plants in mid/late summer instead of bare-root plants in springtime
- We plant biofumigant mustard in spring of plant year to help with nematode problems
- We use a balebuster for applying winter mulch instead of mulching by hand
- We supervise PYO more attentively and move pickers to a "new" field when picking gets tough

Drip irrigation is, probably, the most significant improvement in our production methods. Once you have addressed the filtration challenge, the application of water using "drip tape" has huge advantages over traditional overhead irrigation. Using drip we:

- Supply the crop's water needs without adding moisture to the fruit on the surface, which can contribute to disease problems like botrytis
- We can irrigate efficiently, even on sunny days, during harvest (which cools the fruit, extending shelf life)
- We can address nutritional issues by injecting fertilizers through drip irrigation. (Can even apply biologicals like Double Nickel, Accomplish to improve soil health/prevent diseases.)

The low volume "mega-net" sprinklers have made frost protection easier. We are moving less water at lower pressures so we have fewer "blow outs" and because we are not over-saturating the soil. When the frost threat lasts 6-10 hours we are minimizing the potential of increasings diseases and leaching nutrition.

Using biodegradable mulch (Biotelo) and planting later in the season has assisted in our ability to control weeds during the establishment year. We still need to do some hand-weeding but we have eliminated the use of pre-emergent herbicides and the crop injury associated with it.

The use of plugs, while not cheap, seems to be reducing or eliminating disease problems that may have been coming in on compromised bare-root plants. Also, the planting process is much more simple.

We are not sure how much benefit we get from planting the biofumigant mustard but I think it may be contributing to the longevity of some of our plantings. Some of the plantings are remaining productive for 5 or 6 harvest seasons.

Using a balebuster to apply our winter mulch has the obvious advantage of saving a lot of hand labor…in addition, it enables us to be more precise about applying when full dormancy has been reached. When applying straw to 6 or 7 acres by hand it takes a few weeks and you may choose to start too early so that you finish before the real cold arrives.

During Covid-19 some new rules were put in place by MDAR to ensure adequate spacing and supervision of PYO customers during harvest. We noticed an improvement in how smoothly our PYO business was running. We have continued to have more supervision and space and have found it well worth it.

Decade of Spread: Understanding the Biology, Behavior, and Management of the Invasive Spotted Lanternfly in the US

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The spotted lanternfly, *Lycorma delicatula*, was first detected in Berks County, PA in 2014. This phloem-feeding planthopper has now spread to over 15 Eastern states with infestations as far west as IA. In New England, infestations have been confirmed in CT, MA and RI with sightings reported in NH and VT. This insect has only a single generation per year with adults depositing eggs beginning in September, eggs overwintering until Spring when nymphal hatch begins in April-June. There are four nymphal stages, with 4th instar nymphs molting to adults beginning in July. A polyphagous species, this insect has been confirmed feeding on over 70 plant species in North America with early instar nymphs feeding on a broader range of plant species, compared with late instar nymphs and adults.

When spotted lanternfly first was detected, there was concern for both specialty crops and hardwoods based on reports from South Korea where this insect is also invasive. To understand what host plants would support spotted lanternfly development and survivorship, a series of trials were conducted in laboratory and semi-field trials, and through field surveys. Key findings clearly demonstrated that the invasive tree species, tree of heaven (*Ailanthus altissima*), was a highly favored host for this insect, supporting survivorship and development alone or in combination with potential hosts. Conversely, many hardwood trees such as black locust, black cherry, sugar maple, and white oak could not support survivorship of spotted lanternfly when presented as single host diets, particularly for adults. However, when spotted lanternfly were provided mixed diets of river birch, silver maple, black willow and black walnut, they could complete development in the absence of tree of heaven. Black walnut as a single host can support development to the adult stage.

Fig. 1. Trial aimed at quantifying impact of spotted lanternfly feeding on young peach and apple.

Similarly, for specialty crops, apple and peach could not support survivorship and development of spotted lanternfly when presented as single host diets, but with the addition of with tree of heaven, they reached adulthood. In a large multi-year study, young potted peach and apple trees were exposed to season-long feeding by spotted lanternfly nymphs and adults under field conditions for one season (**Fig. 1**) and then planted and tracked the following season. Horticultural measurements revealed that during early instar nymphal feeding, there was a significant reduction in growth of peach trunk diameter compared with uninfested trees, and the following

year, there was increased susceptibility of peach to frost damage. No acute or longer-term impacts were detected from apple. However, because survivorship is poor on both of these hosts, we are optimistic that spotted lanternfly will not be a significant threat, though excessive honeydew from spotted lanternfly feeding on trees like tree of heaven or black walnut in overhanging canopies bordering orchards can lead to sooty mold growth on orchard trees.

Fig. 2. Spotted lanternfly adults feeding on wine grapevines.

Grape species, however, are very vulnerable to spotted lanternfly feeding with reported impacts in wine grapes (**Fig. 2**) including yield losses and increased susceptibility to winter injury. Spotted lanternfly can complete development on wine grapes, wild river grapes and juice grapes when presented as single host diets, but not on muscadine grapes. Ongoing work to develop IPM tools such as threshold-based triggers for insecticide applications continue. As spotted lanternfly continues to spread, particularly through human-assisted transport, there is concern for not only this crop but also for juice grapes, hops and kiwi.

Because of this spread, the need for reliable monitoring tools is critical. To date, the best trap for monitoring nymphs and adults is a modified circle trap (**Fig. 3**) deployed on tree of heaven or other acceptable hosts such as black walnut, black locust and maple. Traps should be deployed at least a meter above the ground with a kill strip and checked weekly to reduce degradation of specimens. However, a lure to enhance trap captures is currently not available, despite intensive research efforts. Other monitoring and biosurveillance tools such as environmental DNA (eDNA) left behind by spotted lanternfly have provided sensitive techniques to at least detect its presence or absence in areas of concern.

Fig. 3. Circle trap for monitoring spotted lanternfly.

Ultimately, spotted lanternfly remains a threat throughout much of the USA, and as researchers explore ways to manage this pest in vulnerable crops and reduce populations in unmanaged areas using biological control, growers should remain vigilant.

New Thinning Opportunities with Accede™ in Peaches

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Peach and nectarine trees usually bear an excessive number of fruit, resulting in too many small unmarketable fruit at harvest. Annual removal of fruit by hand is necessary to ensure the remaining fruit have sufficient size and quality at harvest. Hand thinning is time consuming and expensive orchard management practice as it requires a significant amount of labour over a short period. This presentation will investigate a novel compound called 1- aminocyclopropane-carboxylic acid (ACC) (Accede™) that is applied to stone fruit trees, around bloom to selectively remove fruit. Also, I will briefly discuss other chemical and mechanical thinning approaches used in the past. The aim of thinning is four-fold: 1) reduced need for hand thinning; 2) reduced need and reliance on manual labour; 3) improve fruit quality, and 4) improved overall orchard efficiency and economic sustainability.

Our first studies with ACC began in 2018 when, in a two-year study we investigated the response of Redhaven peach trees to sprays of 300 and 600 mg L^{-1} ACC applied during the phenological stages of bloom, shuck split and ~15–20-mm fruitlet diameter. The objective was to determine the efficacy of ACC on fruit set, fruit size and yield at harvest, and the amount of hand thinning required at 'June drop'. Although the response to ACC varied between the two years, 600 mg L^{-1} ACC spray at full bloom (2018) and ~20 mm fruit size (2019) reduced fruit set, the need hand thinning by 59–66%, and fruit crop load. Treatments also had varying but significant effects on leaf yellowing and leaf drop when measured shortly after application. ACC reduced total yield and number of fruit per tree in both study years, and increased fruit weight in 2019. Overall, Redhaven trees were responsive to ACC at a range of timings from bloom to approximately 20 mm fruit size.

During the 2021 to 2024 seasons, our focus has been to investigate optimum rates of ACC on three peach cultivars Redhaven, Harrow Dawn and Vivid, and to evaluate ACC for thinning Japanese (*P. Salicina*) and European (*P. domestica*) plums.

In 2021, two experiments were conducted in commercial orchards in Jordan and Beamsville, Ontario to determine the effectiveness of ACC for thinning Harrow Dawn and Vivid peach cultivars. For Harrow Dawn, a rate of 300 and 600 mg L^{-1} ACC were applied at pink bud, full bloom, shuck split, and ~20 mm fruitlet diameter. For Vivid, 300 and 600 mg L^{-1} ACC was applied at pink bud and full bloom. Trees were assed for treatment effects on fruit set, degree of thinning, time and cost to thin, number of fruit removed during hand thinning, leaf phytotoxicity, final crop load, yield, fruit per tree, fruit size, fruit size distribution, fruit maturity and quality, economic value of the fruit, and tree growth. Overall, ACC was very effect for thinning both Harrow Dawn and Vivid trees. Sprays of 600 mg/L ACC caused over thinning while 300 mg/L ACC caused little to no thinning. There was little leaf drop or leaf yellowing and notable negative effects on tree foliage. For Harrow Dawn, ACC reduced the time and costs required to

hand thin by up to 81%. ACC increased fruit size and reduced the requirement for hand thinning, and reduced yield. There was no compensatory benefit in the fruit size and hand thinning savings that led to improved economic outcomes. Consequently, there was no economic benefit realized by the application of ACC. Regarding the time of application, ACC was more efficacious at the pink and full bloom timings than shuck split or 20 mm fruitlet diameter. There were only marginal benefits of ACC in compressing fruit maturity into the first harvest and ACC had no direct effect on fruit quality as expressed as by firmness, soluble solids, or titratable acidity. ACC caused insignificant leaf yellowing or leaf drop. For Vivid, a split application of 300 mg ACC applied at pink and full bloom was more efficacious in thinning than a single application of 600 mg/L ACC applied at pink bud. Depending on rate, ACC reduced the time and costs required to hand thin by 22-74%. While ACC increased fruit size and reduced the requirement for hand thinning, it also reduced yield to a greater extent. Nevertheless, there was a compensatory benefit in the fruit size and hand thinning savings that led to improved economic outcomes. Concentrations of ACC between 284 and 427 mg L^{-1} resulted in optimal gross value of fruit (excluding hand thinning costs). ACC advanced fruit maturity, in so much as nearly 50 to 80 % of fruit could be harvested during the first harvest date, depending on the ACC treatment. ACC had negligible effects on fruit soluble solids, juice pH and titratable acidity. Environmental conditions in April of 2021 were cold/cool and not ideal for applying ACC; consequently, the cold/cool weather prior to and following early applications of ACC may have contributed to increased ethylene production and sensitivity of tree to ACC.

In 2022, a commercial orchard of Redhaven peach trees was treated with one of eight treatments consisting of: i) hand-thinned control (HTC); ii-v) 200, 300, 400, and 500 mg L^{-1} ACC applied at full bloom (FB); vi) 200 mg L^{-1} applied at pink bud and FB; vii) 400 mg L^{-1} applied at pink bud; and viii) 400 mg L^{-1} applied at first bloom. The following treatments resulted in reduced fruit set compared with the HTC: those treated with 500 or 600 mg L^{-1} ACC at FB; a split application of 200 mg L^{-1} ACC applied at pink and FB; and 400 mg L^{-1} ACC applied at first pink. However, there was no overall effect of ACC on crop load (thinning), on the time required to thin trees, fruit number, fruit size, yield or fruit quality at harvest. It is unclear why ACC was ineffective in 2022, but it may be related to variability of measurements in the orchard. In this study, trees were hand-thinned commercially, but to a lesser extent than typical reducing the requirement of ACC thinning.

In 2023, commercial Harrow Dawn and Vivid peach trees were treated with one of nine treatments consisting of: i) hand-thinned control (HTC); ii–iv) 300 mg L^{-1}, 400 mg L^{-1} , and 500 mg L^{-1} ACC applied at full bloom (FB); v–vii) 300 mg L^{-1}, 400 mg L^{-1} , and 500 mg L^{-1} ACC applied at 15-20 mm fruitlet diameter; viii) 150 mg L^{-1} AVG applied at the ‘pink bud’ stage and 300 mg L^{-1} ACC applied at FB, and; ix) 150 mg L^{-1} AVG applied at the ‘pink bud’ stage. Response to ACC varied by cultivar, concentration, and time of application. Harrow Dawn treated with ACC at FB resulted in reduced fruit set and crop load in a linear fashion with increasing ACC concentration. In contrast, applications at the fruitlet stage had no effect on fruit set, but reduced crop load in a linear fashion with increasing ACC concentration. As a result, ACC application at FB reduced the requirement for hand thinning by 43% when treated with 500 mg L^{-1} at FB. ACC applied at the fruitlet stage (~20 mm) had little effect on reducing the requirement for hand thinning. Marketable yields of trees treated with 300-500 mg L^{-1} ACC at FB were similar to the HTC trees yet were reduced by up to 83% when applied at the fruitlet

stage. ACC sprays at both application times resulted in more fruit harvested on the first harvest date. Overall, there was little effect of ACC on average fruit weight at harvest compared with the HTC, fruit quality parameters or leaf phytotoxicity when applied at FB. For Harrow Dawn, applications of 400-500 mg L^{-1} ACC applied at FB were most effective in decreasing the need for hand thinning, with the gross value of fruit comparable to the HTC trees.

Fruit set of Vivid trees was unaffected when treated with ACC at FB and the fruitlet stage (~18 mm), but crop load was reduced in a linear fashion with increasing ACC concentrations. ACC applications at FB reduced the requirement for hand thinning by 11-28%, with the greatest response at 400 mg L^{-1}. ACC applied at the fruitlet stage reduced the need for hand thinning by 34-37%, with an inconsistent concentration effect. Marketable yields were unaffected by either the rate or time of application of ACC compared with the HTC tree, although there was significant variability among the treatments. ACC sprays at both application times resulted in more fruit harvested on the first harvest date, except when 300 mg L^{-1} ACC was applied at the fruitlet stage.

ACC applications decreased total marketable fruit yield by up to 62% compared with the HTC, and the impact increased in a linear fashion with increasing rates of ACC when applied at FB only. However, because of large treatment variation, all treatments had marketable yields similar to those of the HTC. Overall, there was little effect of ACC on fruit quality parameters or leaf phytotoxicity when applied at FB. There was significant leaf phytotoxicity manifested as leaf drop to ACC sprays when applied at the fruitlet stage. This lasted for approximately three weeks. Because of the wide variation in measurements, it was difficult to determine the ideal application concentration of ACC for adjusting the crop load of Vivid peaches and reducing time to thin, while simultaneously optimizing gross value of fruit. Applications of 400 mg L^{-1} ACC applied at FB are likely to provide the greatest reduction in need for hand thinning, but reduced marketable yield led to a 43% lower gross value of fruit for this treatment compared to the HTC. Fruitlet applications of ACC on Vivid are not recommended because of the high level of phytotoxicity observed in this study.

In 2024, commercial Harrow Dawn and Vivid peach trees were treated with one of seven treatments that consisted of: i) hand-thinned control (HTC); ii–iv) 300 mg L^{-1}, 400 mg L^{-1}, and 500 mg L^{-1} ACC applied at full bloom (FB); v–vii) 300 mg L^{-1}, 400 mg L^{-1}, and 500 mg L^{-1} ACC applied at 15-20 mm fruitlet diameter. The Harrow Dawn and Vivid orchards were affected by spring frost where temperatures dropped to -5^{o}C (22.8^{o}F) on April 26th when trees were in bloom. In the interest of research, we proceeded with the experiment, but thinning with ACC after frost is cautioned on the Accede™ label. ACC treatments significantly reduced fruit set and crop load, particularly when applied at full bloom. Fruitlet stage applications resulted in higher fruit set and crop load than the full bloom timing, but still significantly lower than the hand thinned control. In the Vivid orchard, ACC was effective at reducing fruit set and crop load at full bloom, while there was no significant decrease in fruit set or crop load at lower rates of ACC when applied at the fruitlet timing. Applications of ACC at full bloom resulted in the greatest decrease in fruit number per tree, but also increased the fruit size significantly. Only the highest application of 500 mg L^{-1} ACC decreased the number of fruits significantly compared to the hand thinned control.

Further details of our plum research with ACC and guidelines for ACC use will be discussed. Stone fruit response to ACC is complex because tree and thinning response is impacted by environmental conditions, cultivar, and other tree physiological factors.

Growing Organic Peaches in High Tunnels

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We grow HIGH QUALITY ORGANIC apples, cherries and peaches without the use of conventional pesticides or fungicides and very limited use of the organic counterparts. That's right! In wet, buggy New England!

How do you grow high quality organic fruit in a moist, humid, insect inhabited area like ours? By not having preconceived ideas or romantic notions of what an orchard should look like. In other words, you need to be openminded about at growing fruit. First a little about our farm.

Our farm encompasses a total of 14 acres and slopes to the north and west at 8 to 15 degrees where it is open field. Forested areas slope at 15 to 25 degrees. We have great cold air drainage. Six acres are open field and this is where our fruit trees grow. It has great sun exposure, deep well drained soils (Canterbury Fine Sandy Loam) and very high organic matter (6.5%). Our growing area has not been farmed for the last 80+ years. No chemicals (we tested) and relatively rock and boulder free, but some invasive plants. Just the right place to grow fruit.

Apples, peaches and sweet cherries. All stuff I loved to eat. Whole Foods sells organic apples at $4 a pound, peaches at $6 a pound, cherries at a gazillion dollars a pound. Nice prices for just three apples or peaches or a handful of cherries. In 2011 we planted our fruit first trees. That summer, I coverer our trees with row covers, the same material I used to protect veggies to great effect. Low and behold, every part of the tree that grew inside the covers looked great. No bugs and no disease. Everything that grew outside of protection was tattered. That's how I do it. Everything needs to be covered. I knew my life mission – growing organic fruit under cover.

We sold our tiny little experimental farm in 2017 and went on a quest to find real farmland with real fruit growing soils. In 2019 we struck paydirt in the northwest part of Concord, NH. We planted our first trees in 2020. We currently have 160 apple, 60 peach and 60 cherry trees in the ground. This coming spring we will plant another 700 apple trees. The following year, more peaches. When complete, we will have over a thousand trees in the ground. All to be covered in tunnels specifically designed to grow high quality organic fruit. How do I cover a thousand trees? How do I even cover a hundred trees?

Everything starts with tree structure. This is where Italian agriculture is 50 years ahead of farmers in the USA. They shape their trees into a narrow fruiting wall that is no more than two or three feet thick. Trees are supported by a trellis which also supports hail netting. Some of the most progressive orchards are collapsing their fruiting walls to make them even thinner, to less than 12 inches wide. They are also moving away from central leader trees and toward multiple leader trees, known as bibaum or guyot systems. Multiple leaders help to control tree height and lend themselves to a very flat, almost two-dimensional tree. A shorter flat tree means aisles can

be made much narrower. Apple and cherry rows can be planted as close as four to six feet. You might be able to plant peach tree rows just eight, seven or even six feet apart in this system.

Benefits of a fruiting wall:

- Sun and light penetration improve significantly. All of the fruit, from top to bottom color up on almost all sides of the fruit. The percent of high-quality fruit gets close to 100%.
- After a rain event trees dry out much faster, lending to less disease pressure.
- Insect pests have fewer places to hide because the canopy is so flat and open.
- Spray applications more thoroughly cover the tree.
- Tree pruning is simplified. If it sticks out of the wall it gets cut off.
- Mechanical pruning and harvesting becomes much more feasible.

There are some negatives to a fruiting wall, but for me, the benefits are greater.

Benefits of multi-leader trees (bibaum, guyot, etc.):

- One tree takes the place of two, three or four trees. The cost of filling an acre with trees is significantly reduced.
- The more leaders the shorter the tree, making pruning and harvesting easier. Fruit trees like to grow straight up (apical dominance). With each leader that energy is spread out. Our apple trees have six to eight leaders.
- Shorter trees lend to a pedestrian orchard. All of our trees get clipped at eight feet. It has been pretty easy to contain our trees inside the tunnels we have.
- In the eighth year you cut out the largest leader and regrow it. After ten or twelve years you have renewed your entire tree.

There are some negatives to multi-leader trees, but for me, the benefits are greater.

Why is this important for organic grower? A way to grow organic fruit! If tree rows are only six to eight feet apart and a trellis is built to support the tree wall, why not use that trellis to support a roof and insect netting? This is exactly what we have done in our orchard. If apples and cherry tree rows are six feet apart and peach tree rows are eight feet apart, I can easily span the isle width between the rows with a gable roof frame. The roof rafters are attached to the posts of the trellis and hang over the trees. Cover the roof frame with greenhouse film and attach insect netting to the outside of the tunnel and you have an enclosure for growing organic fruit. Pretty simple, very effective.

PEACHES

Most of the experimenting I have done over the last 13 years has been with apples. I love peaches and my wife says a juicy, tree ripened organic peach is almost better than… many things. So, three years ago we planted peach trees with the idea that we could protect them in a similar manner as our apples. For us, the most important outcome is quality organic fruit. At this point I am not so concerned about maximizing yield.

Greg Lang from Michigan State University has done research on tree structure and the employment of multi-leader trees (SSA, UFO systems) with peaches. Jim Schupp from Penn

State University has done research on peach tree spacing. That is the research I can reference for the kind of system I envisioned. Without a commercially available dwarfing rootstock, vigor control becomes a dominant issue. The idea behind our row and tree spacing is based on the research done by Jim – the closer trees are planted the more dwarfing they become. Greg's system calls for multi-leader trees that get severely pruned during the growing season.

Orchard Setup: Each tree row is 120 feet long and 8 feet apart. There are 15 trees per row. Each tree is spaced 8 feet apart within the row. Each tree has 6 leaders spaced 16 inches apart along a cordon growing out from the trunk in opposite directions. All of this is supported by a trellis system.

Pruning and thinning: Each leader was pruned to 20 branches that are 8 inches long. Each branch was thinned to 2 peaches. The goal was to have 240 fruit per tree, 3,600 fruit per row. That equates to about 2,400 pounds of fruit per tunnel. Pruning happens all season long and a heavy pruning happens once a month.

Trellis and roof: The attached roof system is the same design as our apples, just wider. There is one difference we employed this last summer. Plastic covered 70% of top with netting over a gap down the center. The idea was to catch some rain in the center walking isle. Peaches can be attacked by Spotted Wing Drosophila so 70-gram netting is needed for exclusion.

Spray Regime: Micronized copper (Peach Leaf Curl) and dormant oil spray (aphids) well before bud break. Nothing else. We don't want to attack anything until we knew what to attack.

What Happened?

Greenhouse film and netting went up later than I wanted it to, about a week after the end of bloom. We had lots of Plum Curculio damage. Fortunately, we had a lot of fruit to thin and hit our goal of two fruit per branch (Greg Lang's system calls for one peach per branch). Any fruit growing on the leaders was removed.

The first half of the season was very wet and we lost peaches to Brown Rot. As the summer progressed, it dried out a bit which lessened disease pressure. We ended up losing half of our fruit. The netted gap down the middle of the roof sprayed water on the trees more than it watered the center of the aisle. In the end, we harvested 1,200 pounds of fruit over the course of an 8-week season. Harvest happened as fruit ripened.

Remedies & Conclusion

Netting and film will be unfurled as soon as I am confident there will be no more snow. And, the whole roof will be covered in film (no center gap), stopping all moisture from entering the tunnel. Early net-drop should exclude Plum Curculio. Brown Rot, which requires free standing water from rain, dew or irrigation to do its nasty thing, may be significantly reduced or eliminated. An organic spray (Serenade?) will be used as a preventative for Brown Rot. Weed barriers will be installed to eliminate weed growth and cover any Brown Rot disease inoculum.

This was our first year harvesting peaches. As we gain more experience under this system our results will get better. We now know we can sell organic peaches at $6 or more a pound with ease. If we can get close to the theoretical 1,200 pounds of fruit per row, that's $14,400 in revenue per tunnel. We will be putting in more peach tunnels, for sure.

"Low hanging fruit": How Nutrient Management Can Improve Organic Tomato Production in High Tunnels

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Tomatoes are the most widely grown high tunnel crop in the Northeast because they utilize vertical space well, have strong market demand, and tunnel production significantly improves yield, quality, and profitability when compared to field grown tomatoes. However, managing tunnel soil health for optimal production year after year can be challenging. High tunnels create a distinct growing environment with altered soil health characteristics due to the intensity of production, high inputs, and lack of rainfall. Furthermore, many growers are limited in their ability to implement fundamental soil health practices such as crop rotation and cover cropping due to year-round production. Many organic tunnel growers have instead relied on a long-term soil building approach, with high applications of compost, mulches, and other organic amendments. Over time, these practices lead to high organic matter levels and soils that are highly buffered with excellent water and nutrient retention, but can also have excessive/ unbalanced nutrients and high salt levels.

Since high tunnel soils behave quite differently than field soils, using field-calibrated soil tests often underestimates the nutrient needs of tunnel tomatoes and can lead to deficiencies (Grubinger, 2012; Hoskins et al., 2016). The University of Maine Soil Testing Service offers a high tunnel soil testing package ($30 in 2024) that accounts for the unique nutrient needs of tunnel crops. UMaine integrates the modified Morgan's solution, which measures extractable nutrients (typically for field soil tests) with the saturated media extract (SME), which measures water-soluble nutrients and is typically used for potting media (Hoskins et al., 2016). Taken together, these two types of nutrient extraction methods help a grower predict the amount of nutrient immediately available to a quickly growing tomato transplant as well as the amount of "reserve" nutrients that will become available to the plant over the season. Tissue tests are also used by some growers to monitor plant nutrient status during the growing season. The fertility recommendations that accompany test results are intended to close the gap between optimal crop nutrient needs and what is already available in the soil.

Tomato transplants going into tunnel soils are typically big plants that are ready to grow—but they need the available nutrients to do so. Nitrogen (N) and potassium (potash, K_20) are key nutrients for a successful tomato crop throughout the vegetative and fruiting phases. Phosphorus and other nutrients are also critical, but in organic systems these are often in abundance through additions of compost. However, these nutrients are not to be ignored, so recommendations from soil tests are important to pay attention to.

N APPLICATION RATE BASED ON YIELD GOAL

Yield Goal	Yield Goal (lb/Acre)	Yield (lb/ft^2)	Yield lb/stem (4 ft^2)	Approx. plant height	N need lb/acre @ 90% recovery	Total N need lb/1,000 ft^2
Low	40,000	1	4	8'	100	2.3
Medium	80,000	2	8	12'	200	4.6
Good	120,000	3	12	16'	300	6.9
High	160,000	4	16	20'	400	9.2

K_20 application rate based on modified Morgan's soil test result and yield goals

Yield Goal	Low (<400 lb/A = <200 ppm K)		Medium (400-800 lb/A = 200-400 ppm K)		High/optimum (800-1200 lb/A = 400-600 ppm K)		Excessive (>1200 lb/A = >600 ppm K)	
	lb/acre	lb/1000 ft^2	lb/acre	lb/1000 ft^2	lb/acre	lb/1000 ft^2	lb/acre	lb/1000 ft^2
Low Yield Goal	300	6.9	200	4.6	100	2.2	0	0
Medium Yield Goal	450	10.3	300	6.9	150	3.4	0	0
Good Yield Goal	600	13.8	400	9.2	200	4.6	0	0
High Yield Goal	750	17.2	600	13.8	300	6.9	0	0

source: New England Vegetable Mgt Guide

The amount of nitrogen and potash applied should be adjusted based on yield expectations; vigorous and longer season crops (like a grafted hybrid) require more than shorter season crops (like a determinate). The nutrient demands of tunnel tomatoes can be achieved with organic materials through a combination of preplant fertilizing, sidedressing, and via drip irrigation ("fertigation"). In organic systems, about 2/3 of the recommended N can be applied in the form of a seed meal (soybean, alfalfa, peanut) when the soil is warm and moist about two weeks before planting. This allows time for the N in the fertilizer to mineralize into plant available forms. The seed meals will continue to mineralize and provide the tomato plants with N for many weeks.

Similarly, K_20 rates should be applied in alignment with the yield expectations of the crop, but it is important to note that even at the "low" yield goal, K_20 tunnel rates are higher than typical field rates. 100% of the K_20 can be added before planting, although using a blend of potassium sulfate "fines" and standard potassium sulfate is a good technique to ensure long term availability. Water is critical for uptake, so make sure plants have adequate drip lines (up to 4 per plant, especially on sandy soils). Check the lines regularly to make sure they are flowing! Many growers don't notice deficiency until the fruit is nearly ripe and this can dramatically reduce marketable yields.

The remaining 1/3 of recommended N and additional K_20 can be applied via fertigation 4-6 weeks after transplanting. Many organic growers fertigate with fish emulsion (2-4-1) on a regular basis, which provides the plants with a steady low dose of N. This can cause clogging of drip tape, so be sure to check lines and flush regularly if this is a preferred material. Low-cost choices many growers use are dissolved sodium nitrate (15-0-2) and potassium sulfate fines (0-0-51). These products are immediately available for plant use when delivered through the drip but can contribute to soil salt levels. The fertilizer industry is offering more choices for soluble organic

fertilizers made from hydrolyzed soy protein, so check with your supplier for options. A weekly dose of 0.25 lb of N and K_20 per 1000 sq feet is a good starting point for growth maintenance. If fertigation is not possible, it is also useful to sidedress with the remaining 1/3 of the N in a granular form 3-4 weeks after transplanting. Again, be sure adequate water is available to help mineralize nutrients for plant uptake.

Paying attention to soil test results and fertility in organic high tunnel tomato production can lead to vastly better yields and fruit quality. In a 2-year study conducted by UVM Extension (2020-2021) in which UMaine soil test recommendations were implemented in 46 tunnels, growers directly attributed improvements in yield and quality to the fertility recommendations. Taking the simple steps to adjust nutrient management by using the UMaine high tunnel soil test and implementing the recommendations is an easy way for growers to reap the rewards from an abundant and beautiful tomato crop.

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Novel non-chemical weed control tools: performance, safety, and factors influencing adoption

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Weeds threaten the $79 billion specialty crop industry in the United States (US) by reducing yields, harboring pests and pathogens, and complicating harvest efforts. While many growers in the US rely on herbicides for weed management, organic field and specialty crop growers must address these challenges without the aid of synthetic crop protection chemicals. Organic weed management practices focus on minimizing weed growth through sustainable methods that enhance soil health and biodiversity. Techniques include crop rotation, cover cropping, and mulching. Hand weeding and mechanical cultivation are also commonly employed.

In response to these challenges, numerous companies are entering the agricultural technology sector to develop and market innovative tools aimed at improving weed control while reducing or eliminating reliance on synthetic herbicides, intensive soil disturbance, and extensive hand weeding crews. Between row mowing and electrical weeding are some tools that have been explored in organic systems. Robotics companies with GPS and artificial intelligence driven tools are also operating on many farms. Notable firms include Burro, Farm-ng, and Naïo Technologies (which focus on autonomous platforms and weeding robots); K.U.L.T., Stout, and Farmwise (vision-guided cultivation technologies); Verdant Robotics, Ecorobotix, and Mantis (precision spraying); and Carbon Robotics and Escarda (laser weeding), among others. Research trials to evaluate new technology are not extensive, but more literature is becoming available. In addition to weed control performance and crop safety, potential adopters should consider multiple other factors ahead of purchase or use.

Cost
Weeding units can range from tens of thousands to over a million dollars, alongside ongoing costs for parts and services, especially for companies without local bases. Would adopting new technology require substantial changes to production parameters, such as new equipment for altered row spacing or planting methods?

Adaptability and Versatility
The differences between Western and Eastern U.S. farms—such as soil types, terrain, weather, field sizes, and available capital—raise questions about whether these technologies have been adequately tested in local conditions. What adjustments are necessary to assure New York growers that these tools can be effectively integrated into existing crop management practices? Are these technologies versatile enough for multiple crops, or are they designed for specific conditions?

Infrastructure and Labor
Are New York's cellular and internet services capable of supporting current and future technological needs, including GPS with RTK correction? Do farms have personnel skilled in mechanics, electronics, and programming to operate and maintain new technologies?

What to Do If Approached by a Company:

Engage Repeatedly
Interact with companies before making commitments. Request demonstrations under various production conditions and gather your own data on performance and crop safety. Calculate your own return on investment (ROI) rather than accepting figures at face value, and discuss potential buy-back programs to safeguard against obsolescence.

Cost Control Realism
Understand that while reducing costs may be ideal, effectively controlling them is often more realistic.

Collaborate with Industry
Acknowledge that technology companies may not fully grasp the unique challenges faced by specialty crop growers. Work with industry partners to refine tools, but don't take on their research and development responsibilities. Collaborative efforts can be beneficial, but avoid overcommitting.

Data vs. Information
Many companies can offer growers data from in-field operations, but it's essential to differentiate data from actionable information. Learn how to access your field records and integrate them effectively into your weed management strategies.

Assess Your Risk Exposure
Risk is inherent in this process, but avoid overextending yourself. Determine whether direct sales or service contracts suit your needs better. If you opt for ownership, ensure you have a team that is comfortable with the technology, which may involve familiarity with mechanics, electronics, programming, and data analysis.

Understand Company Dynamics
Be aware that companies often balance customer needs with investor interests, which can create tension.

Continuous improvement – how organic standards affect your farm, and how you can influence them

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Plastic mulch, paper pots, coppers, micronutrients, compost, organic seeds… Do you ever wonder why you can use some materials but not others? Why does your Organic System Plan ask questions on soil fertility practices? How are organic standards defined and how do they change?

Organic standards are created, updated and changed by the USDA National Organic Program (NOP) with recommendations from the National Organic Standards Board (NOSB). The NOSB is an advisory board to the National Organic Program and is composed of citizens representing different parts of the organic industry. It plays a crucial role in integrating comments from the organic community into the organic regulations.

This talk will cover why the NOSB is important to you, ways you can have input into the organic standards that affect your farm and business, critical decisions currently before the NOSB, and important rulemaking being done by the NOP that will be impacting practices on your organic farm or handling operation. Your comments to the NOSB and NOP can change how organic rules are worded and applied!

Organic Mechanical CPB Management at Goranson Farm

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Göran Johanson with information from Carl Johanson and Rob Johanson.
Here on Goranson Farm we have been growing potatoes since the early 60's when our Grandparents moved down from northern Maine, known to Mainers as "The County." In the 90's our parents, Jan Goranson and Rob Johanson transitioned the farm to organic production growing up to 14 acres of potatoes in addition to mixed vegetables. Our farm now produces around 4 acres of potatoes and 30 acres of mixed vegetables marketed through farmers markets, wholesale accounts, our on-site farmstand and a year round CSA.

CPB management on Goranson Farm has become extremely challenging for us over the past 10 years. Our go-to organic insecticide for CPB management was Entrust. The pest has now become resistant to the insecticide, this is most apparent at the adult stage. This led us to look for other control options for adults and mature larvae. We have started using a mix of Mycotrol ESO and mechanical suppression for control until row closure. At that point of growth, we would be doing more damage than good with mechanical control.

We developed a system using agricultural propane burners. The goal is to not burn the CPBs to death but to merely torch the antenna and feet so that they cannot climb back up the plant and continue feeding(eventually dying from injury or starvation). Our first step is using our stale seedbed burner to burn emerging potatoes from ground crack to around soft ball size. Even if all the plants have not emerged it is important to not burn too late as it can have a pretty harsh effect on potato vigor post burn. This primary burn is across the full bed, for both weed control and to injure any adult CPBs that may be present.

The second step in our system is based upon using both front and belly mounted "beetle beaters" to brush the potatoes side to side, knocking the live beetle bodies into the bed center and wheel tracks. These beaters are "on the go" height adjustable as top height can vary in the 8-10 varieties we grow. This side to side action is then followed up by a rear mounted 3 point burner that we modified for this application. This between-row burner has two Red Dragon burners located in the bed middle and one burner directed at each of the wheel tracks. We are running the burners at 30 PSI and have a 40 lb propane tank that is sufficient to cover 2 acres at a ground speed of 4.5-5 mph. Shields have been put in place to lift foliage out of the control zone as well as protect the upper foliage from damage. This system, when used based on scouting, two times per week, has been an effective CPB control of both adults and larvae for over the past fifteen years .

We do have some issues with this system we want to address. First, we will be adding a second burner behind each wheel track to have the ability to angle the burners so they fire directly at the base of the potato plant (which is not damaged if ground speed is controlled properly and shields are in place). This is a two fold modification for better in-row weed control as well as targeting any larvae or adults that fell directly down to the base of the plant and not into the wheel tracks or bed center. Our second modification is to increase our fuel supply so we can burn more acres

with this system in one go as well as to make up for the additional fuel usage of the two burners that will be added. Overall this has allowed us to reduce our reliance on Entrust or other BT sprays for control of the CPB. Also, it will help reduce the population of resistant adults. We now have a susceptible population again which has allowed us to use a combination mechanical control, Entrust and a few other sprays. We will continue spraying only for young larvae (1st and 2nd instars) and for post row closer control or in combination with Pyganic 5.0 for the control of leafhoppers.

On-Farm Innovations for Colorado Potato Beetle Management Beyond Entrust

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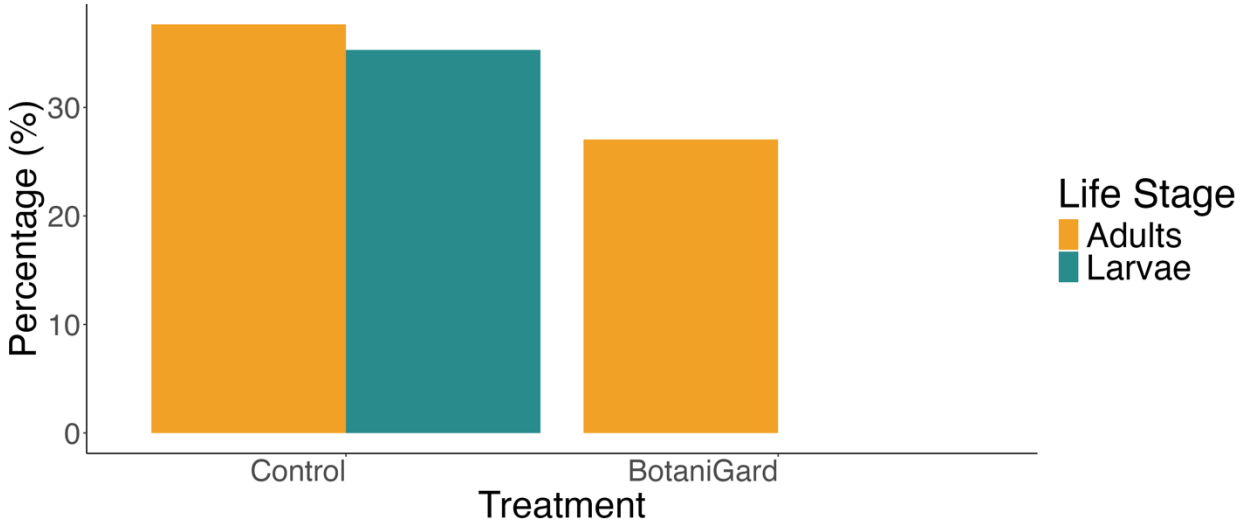
The Colorado potato beetle (CPB), a persistent and destructive pest in northeastern vegetable farming systems, poses significant challenges for both organic and conventional growers. Known for its high reproductive rate and rapid adaptability, CPB has become resistant to a variety of insecticides, leading to substantial crop loss, particularly in potato and root crop production. Effective, low-impact control options are essential for organic farmers, who are especially interested in alternatives to synthetic chemicals.

One promising biological control agent is *Beauveria bassiana*, a naturally occurring entomopathogenic fungus that infects and ultimately kills insects upon contact. Known for its safety and specificity, *Beauveria* has the potential to significantly reduce CPB populations by targeting both larval and adult stages, making it a valuable tool in Integrated Pest Management (IPM) strategies for organic farming.

This past summer, we conducted a field trial across four Vermont farms to evaluate the efficacy of BotaniGard active (ingredient: *B. bassiana*) in managing CPB populations. Early results indicate that *Beauveria* applications effectively reduced CPB densities across various life stages, notably decreasing larval and adult populations. These findings suggest that BotaniGard can be an effective addition to organic farmers' IPM strategies, offering a sustainable solution to manage CPB without relying on conventional pesticides.



This chart illustrates the percentage distribution of larvae and adults within each treatment (Control and BotaniGard) on the final sampling date (late July). In the Control treatment, larvae made up 35.3% of the total population, while no larvae survived under the BotaniGard treatment.

Regain Control of Your Tunnel Through Automation

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There's no silver bullet to get a comfortable living wage without sacrificing your life for the farm. BUT, there's a process successful farmers have in common. We also tried it and it changed our business at Orisha. That process is not a well-guarded secret. In fact, it's a cliché: Do more with less. If you are like me, you might think: "Yeah. Sure. How am I supposed to do that?"

If you are like most farmers, you already feel overwhelmed with all you have to do. Survival mode often comes up. So how can you make change happen when you don't have the room to think?

The insight comes from what a farmer told me: "Nothing's hard. What's overwhelming is the sheer volume of easy tasks."

That made me notice that the process successful farmers follow is to cut these small tasks. One after another. There's no big, never-ending project. Just small incremental wins that become a virtuous circle. The 5-minute/week recurrent task you cut adds 5 minutes every week to think about eliminating the next task.

To get the wheel started, I'll cover 3 areas you can improve in 5 hours using tunnel automation:

- The mental burden of uncertainty
- The productivity killer
- The wasted tunnel potential

The mental burden of uncertainty

Uncertainty and lack of control are 2 excellent ways to burn out. I'm sure decision fatigue is a concept familiar to any farmer. That's why the first reason to consider automation is mental health!

The other day I read: "We were too busy carrying heavy stuff to invent the wheel." Feels too accurate? That's why I want you to free your mind. You need space to find creative ways to eliminate more time-consuming tasks on your farm.

By delegating the growing conditions in your tunnels to a service designed for it, you can cut a bunch of micro-decisions: Will I be back in time to close the side before the thunderstorm hits? Should I go check out if it's too warm in there? Has someone watered the plant today? It's quite sunny, do my crops need more water? What temperature should I keep in the greenhouse? Have my staff turned the ventilation on?

Tiring, right? It feels like little things but they compound! You want you and your staff to be productive? Get the micro-decision out of your head.

Once you automate, the only remaining question is: Has the automation done what it needs to do? And you don't have to worry about that since you'll get a call when something goes wrong. Then, you can see what happens and take remote actions on your phone from wherever. I won't lie, it's not perfect. Most farmers prefer one situation a year to daily questioning though. Especially when they get quick support to fix it.

The productivity killer

The second enemy you want to tackle bears the evil name of interruptions. It's a bit like the constant questioning above, but it's not about freeing space to think. It's about freeing time to get everything done and still have time to invest in small farm improvements. All that within a comfortable workweek. That's the goal anyway.

How many times have you wondered where the time has gone? Once again, it is generally a bunch of little things. The common wisdom knows: the devil's in the details.

When I ask folks how many times they have to go to their tunnels, it's generally very little. When I press with questions though, we realize they don't spend much time on their tunnel as long as the conditions are perfect. More often than not though, there are way more back and forths: A storm's coming. It's cold but the sun will burn transplants. Oh. It hid behind the cloud again…

In general, people tolerate this because it's not obvious. The problem appears when you stop to measure. These sneaky interruptions turn out to cost way more than we think.

Every time you get interrupted and need to walk, it's time lost to walking. Then you notice a problem on the farm and get distracted. An employee sees you and asks a question. Then you walk back to what you were doing. You realize your teammate got slowed down because they needed your help to move the tarp efficiently or whatever... The little things, right?

Consider this: 1 hr/day of productivity lost is $5000/yr wasted in labor. Or it is the difference between a 55 and a 48-hour work week. People don't realize it until they try it. Hands-free ventilation and irrigation are game changers on a farm. Oh! Have I mentioned that this is essential to get some kind of weekend during the season? That too is hard but very possible!

The wasted tunnel potential

In Quebec, there's a lot of grant money to support small farmers. A great expertise for greenhouses resulted. We now see market gardeners grow 4 times more than everywhere else. For a heated 30x100' high tunnel, that's about $40,000.

Why am I talking about that? Maybe you don't want to develop more customers to sell these extra tomatoes? That would add to your mental load. Fair point. Now, imagine if you could get the same output from 1 tunnel than 4. Would you need to sell as much if you didn't have to pay for the 3 extra tunnels? Would you save time maintaining them? In fact, small farms in Québec have far fewer tunnels than elsewhere... despite the available grant money!

“How can I increase my yields using tunnel automation?" you ask. Getting a call before cooking your plants is a good start, but you’ll do better than that. You can prevent temperature swings and thermal shocks. You can keep the heat in during the shoulder seasons. You can also adjust the temperature to the sunlight received. This will balance your crops' growth. Without going into details, that all contributes to more output for the same input.

Next, you can get fungal disease prevention out of your hands. Your automated tunnel will ventilate up to 30 times a day to keep the humidity in check. Especially useful since you probably sleep at night and that’s when it is the most humid. With this, you can keep productive plants longer in the fall. On top of this, you'll reduce losses and sprays during the season. With, lower humidity level, you can even increase the density and boost your income per square foot!

All that appears daunting, but all you need to do is to let the machine do the work for you.

If you’d like more tricks to increase yields, you’ll have to check out the Maximize your Greenhouse Income ebook at orisha.io/tools.

What if I consider automating my tunnel?
My recommendation: start by getting the roll-up sides out of your head. Most farmers think it won’t make much of a difference. Try to take it from them after they’ve tried it and see!

There are other low-hanging fruits. With a 5 hour budget, you can get all these up and running:

- Side ventilation
- Disease prevention
- Irrigation
- Heating
- Rain protection
- Wind protection

While you can get even more off your plates by automating louvers, fans and peak vents, it’s not as easy since it often involves higher voltage.

Wondering about the price? You can get everything you need to automate the side ventilation of a tunnel for $125/month. Down to the screws. And if it doesn’t pay for itself, you have 60 days to get your money back. Don’t worry, you’ll know within a week!

Conclusion
What successful farmers have in common is how they find ways to get the little things out of the way. Getting your tunnel out of your head is one of the quick wins you can have to get the virtuous circle going!

Earning a decent living on a farm is tricky, but each baby step makes the way there easier and easier.

For more concrete tricks to create space on the farm, check out the ebook at orisha.io/tools. In there, you’ll find what moves Antoine made to get his farm profitable within a 35-hour week.

If you’d like support to get the benefits of tunnel automation on your farm, do not hesitate to reach out!

Robot Invasion from Denmark: Solar Powered Help for Seeding & Weeding

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Agricultural Robotics

Automated field robots for seeding, cultivation, and spraying are no longer the realm of science fiction. There are several commercially available products, of varying degrees of complexity and usability. A key motivator is input cost reduction, including the cost of labor. A key factor in adoption of this technology is the ability of a farmer to operate the machinery themselves, something that FarmDroid has managed to incorporate into their offering.

FarmDroid

FarmDroid has been producing and selling the FD20, an entirely solar-powered direct seeding and mechanical cultivation robot since 2019. With over 500 units in operation, FarmDroid has achieved a certain commercial viability not often seen in agricultural robotics. From a side project started by two brothers (who are still involved in daily operations at the company), FarmDroid has grown to a full-fledged company, recently securing an $11 million investment to add more staff and further develop its product.
This year, FarmDroid partnered with both Oregon State University and Michigan State University to grow kale, cabbage, turnip, rutabaga, and beet trials. The trials took the form of a feasibility study, working across a handful of acres at each site. Next year promises more of the same, and hopefully some use across broader acres in partnership with farmers neighboring the research locations.

FD20 Operation

FarmDroid FD20 is a solar powered field robot that seeds and weeds. By using high precision RTK GPS, the FarmDroid FD20 marks the position of each plant in a pattern before placing the seeds and subsequently performs both in-row and between-row weed control, by repeated mechanical cultivation of a thin top layer. The robot communicates with a dedicated RTK GPS base station, maintaining 8 mm accuracy across the field. Because of the existing seed pattern and precision of the robot, it is possible to leave the robot to operate in an automated manner, as it avoids weeding the plants that it placed. Since there is no reliance on camera systems to detect weeds, the FD20 can be turned loose to weed earlier than any camera-guided weeding system. It can even remove weeds that have yet to emerge and requires no difference in size between the plants and weeds. It can cover about 16 acres in a day; if more coverage is needed it is possible to have multiple robots working in the same field.

Compatible Crops, Considerations

A list of crops that have been successfully handled by the FarmDroid follows:
beetroot, broccoli, cabbage, carrot, cauliflower, chicory, coriander, dill, hemp, kale, onion, parsley, radish, rapeseed, lettuce (various), spinach, sugar beet, turnip. You can of course with a little imagination expand this existing list to many other similar crops, which will as a general rule be compatible as long as seeds are less than 9 mm in their largest dimension. For irregular or particularly small seeds, better results are achieved with pelleted seed. In-row weeding can be done for seedings with a spacing of 4”or more in-row, and rows 22.5 cm apart (a little less than 9”). Field preparation is critical to ensure good seeding, and most farmers finish with a cultipacker or something similar to firm the loosened tilled seedbed a little bit before seeding. This ensures consistent depth and good seed to soil contact.

Are You a Viking?

FarmDroid is early in their development of their North American market, making forward strides through a strategy called the Viking Program. FarmDroid is looking for open-minded farmers with a natural aversion to the phrase “we’ve always done it that way”. The intention is to get their robots into the hands of capable and innovative farmers who are willing to share their candid feedback with FarmDroid and other farmers, further refining the product for the US market and generating word of mouth along the way. In exchange for that help, FarmDroid is offering their FD20 robot to Viking Program participants at reduced prices and on more flexible payment terms. Feel free to contact Dane Watson or FarmDroid directly with any questions or to express interest, we will be happy to talk to you!

NEWA: sensors, forecasting models, and decision-making tools for climate resilience

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What is NEWA?
NEWA collects weather data through the Internet from weather stations primarily located on farms and generates real-time weather data summaries, crop production tools, and IPM forecasts. NEWA tools promote better IPM, reduced pesticide use, and improved environmental protection. NEWA provides science-driven and accurate data, so that producers can make informed decisions and reduce crop production risk. Website: newa.cornell.edu

Get an on-farm weather station
You have two options…Onset or KestrelMet (formerly Rainwise). It's like buying a car, both have different features and limitations:

- ONSET
    - Wired, wi-fi, cellular connection options
    - Modular, sensors are plug and play
    - Soil temperature, moisture sensors can be added
    - Capability to expand with Hobonet

- KestrelMet
    - Cellular or wi-fi
    - All-in-one design
    - Has a nice soil temperature/moisture array ($$)
    - Needs recalibration?
    - No ability to expand?

On-farm weather data collected includes the following installed sensors: temperature & relative humidity/dew point; rainfall; wind speed and direction; solar radiation; and leaf wetness. Optional: soil temperature and moisture. Sensor values are uploaded to NEWA every 15 minutes and archived on NEWA.

Contact your NEWA State Coordinator with questions on weather stations:
https://newa.cornell.edu/partners

NEWA 3.0: Step-by-step

- Sign up and login
    - Sign up (if not already done so)
    - Login
    - Edit Profile
- Edit profile
    - Personal Info
    - Favorite Stations
    - NEWA Tools
    - Other Tools

- Dashboard
    - My Favorite Stations
    - Current Conditions
    - Weather Forecast

IPM crop forecasts (examples)

Tree fruit
Apple scab (Figure 1.) and **fire blight** tools use temperature, precipitation, relative humidity, and leaf wetness in very robust models to help determine the risk of infection which can help time fungicide and antibiotic sprays. The **codling moth** model uses temperature to calculate degree days from adult flight and mating to egg hatch to optimize insecticide sprays.

Vegetables
In vegetables, the **cabbage maggot** tool uses base 40°F BE degree days to identify the critical treatment timing before cabbage maggot can infest crucifer crops. Treatment guidelines include organic options. In **onions**, risk assessment tools forecast the infection potential for Botrytis leaf blight or blast, onion downy mildew, and purple blotch.

Grapes
Manage **grape diseases** with infection risk tools that also provide management guidelines for black rot, Phomopsis cane and leaf spot, and powdery mildew. The **grape berry moth** degree day tool estimates development of grape berry moth generations, identifies treatment windows, and provides management guidelines.

Berries
The **blueberry maggo**t tool uses base 50°F BE to predict adult emergence and enhance your ability to use IPM to determine if insecticide treatments are needed. Optimize fungicide applications for **strawberry fruit rot** diseases, this tool predicts the optimal timing of fungicide applications for anthracnose and grey mold based on temperature and rainfall.

IPM weather tools
Easily review and download historical weather data, including daily summaries and hourly. monthly summaries of maximum/minimum averages. Useful in, for example: minimum winter temperature, rainfall (extremes), wind speed and direction (for spray records), etc.

Infection Events Summary

Download CSV

Events: Dry Wet

Date (2024)	Infection Events	Average Temp (°F) for wet hours	Leaf Wetness (hours)	Hours > 90% RH	Rain Amount
May 13	no	50	11	2	0
May 14	no	54	8	0	0
May 15	combined	62	18	0	0.15
May 16	yes	58	16	7	1.03
May 17	no	55	8	3	0
May 18	combined	59	12	0	0.09
May 19	yes	57	12	1	0
May 20	no	56	9	0	0

Figure 1. Example NEWA 2024 apple scab infection events for May 15, 2024, Belchertown, MA.

Transforming Farms with Tech for Efficiency & Peace of Mind

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Technology is a growing presence in agriculture, offering many benefits and features. However, it can also be expensive and aimed at larger operations. There are, however, many ways to integrate technology into your farm regardless of size that can help improve key aspects providing cost savings, increased efficiency and peace of mind.

Sensor Systems

One of the cheapest forms of useful farm technology is sensor systems. Offering valuable data gathering and insight into your growing environment aside, the main perk of these systems is emergency alerts based on thresholds you set. Everything from temperature to door positions can be monitored allowing you to get real time feedback if a compressor fails or a door is left open saving thousands in lost or damaged product.

Many sensor systems require Wi-Fi to be present to operate, but better systems can transmit long range wireless signals allowing to place sensors over a thousand feet from your internet source. Cost will vary depending on the type of sensor and if it needs to handle a wet/dusty environment, but most will cost you $100-$250 each with some form of main controller/base station plus a yearly subscription. A good example would be a Monnit system that has a $220 base station, $45/year starting subscription and the outdoor rated temperature sensors costing around $200 each.

Determining return on investment is simple. Think of sensors like insurance and add up what they are protecting and what could be lost in different scenarios over a 5-year period. Essentially you are performing risk analysis and determining if a sensor in a certain location will save more than its value over a certain period of time.

Camera Systems

Everyone knows camera-assist with security, but have you thought about all the other uses they can be useful on your farm? Cameras are an integral part of Pleasant Valley Farm helping us improve systems and processes as we can review the footage later watching for inefficiencies. They also allow us to go back and calculate time on tasks and projects, saving the arduous process of having employees document their time during the work day while you figure out costs of production.

Cameras allow you and employees to keep track of the entire operation and reduce the need to communicate about statuses and conditions, saving time and improving efficiency. Monitoring animals is another key use case allowing review of past issues and saving valuable time checking

in during nights and weekends. There are dozens of other uses and most people find cameras to be one of the best things they've ever added to their farm.

Cost varies, but most good long lasting systems will be $1500-$2500 to start. Look for systems that don't have ongoing license fees from reputable companies that will be there in the long run for support. Many consumer and off the shelf brands are not good long term investments and are rarely kept updated for more than a few years.

Return on investment is a bit more complex than sensor systems, but often all it takes is a few events over a couple years to pay back the initial cost.

Wi-Fi Systems

A critical component of almost every farm today is the internet. Getting internet where you need it reliably is often a challenge. Fortunately there are many solutions available if you know some basics.

Most people have heard of Wi-Fi extenders, but while these may be inexpensive, they are often the least reliable. Wi-Fi Mesh is a more robust solution if your distance between the mesh repeaters isn't too far (75-100 feet is far for Wi-Fi).

The best long term, reliable and cost-effective solution is wireless bridge (you'll also hear the terms "fixed wireless" and "point to point bridge") equipment. Essentially two devices pointed at each other with directional antennas that allow for long distance (think miles if no obstructions), dedicated communication. Just like if you ran a wire between the two locations. A little bit more technical knowledge is needed usually to get these devices connected, but the results are superior. Cost will vary depending on the situation but expect around $300 in equipment to connect two buildings as a starting place.

Avoiding Aphid Outbreaks on High Tunnel Tomatoes

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Don't let your summer high tunnel crops succumb to another aphid apocalypse! Several species of aphids can cause problems on high tunnel crops. The most common aphids that can be found infesting high tunnel tomatoes are potato (*Macrosiphum euphorbiae*), foxglove (*Aulacorthum solani*) and green peach (*Myzus persicae*). In high tunnels, aphids can be winged and wingless. Aphid populations in tunnel settings are usually all female and they reproduce without mating (asexually). This allows their populations to explode if left unchecked. Aphids have piercing-sucking mouthparts and they feed on plant sap. This causes leaf distortion, stunting, and discoloration. Aphids produce honeydew, a sticky substance that allows for the growth of sooty mold (Fig. 1). As the aphids grow, they leave white cast skins behind.

Fig. 1. Potato aphids infesting a high tunnel tomato plant (above). Cast skins and sooty mold (below).

Aphid outbreaks are avoidable and timely scouting to find patchy, problem areas and early interventions can reduce the risk of future damage. IPM (Integrated Pest Management) relies on a combination of strategies (i.e., cultural, scouting, biocontrol) to prevent pest populations from reaching damaging levels. As spring arrives, many growers are transitioning to warm season crops. This is a critical time to scout remaining winter crops as they are being removed, especially if tunnels were in leafy greens production. If greens were infested over the winter, a brief fallow period in spring should be considered prior to planting spring crops. If tunnels were fallow since fall, removal of any crop debris and weeds is paramount to remove any aphids that overwintered. If you obtain seedlings from other growers, inspecting them upon arrival is critical to detect any hitchhikers. On our High Tunnel Production Toolkit website (https://www.uvm.edu/~htunnel/), there are several resources to assist with scouting. These include a scouting checklist, several datasheet types and some tips and critical questions to consider if pests are becoming a persistent problem. If aphids are found, it's important to have them identified because some of their natural enemies tend to be aphid-species specific. Send specimens to your Diagnostic Clinic for id or contact your local University Extension specialist.

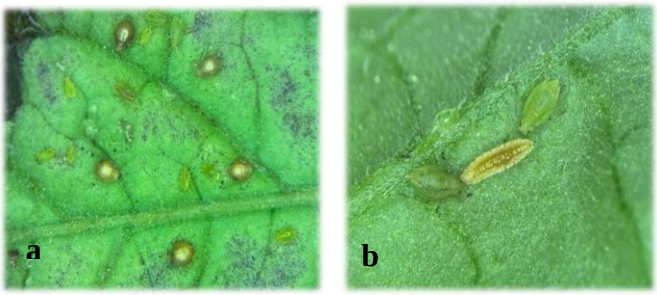

Fig. 2. Aphid mummies (a). *Aphidoletes*

A well-thought-out release schedule with deliveries throughout the season is key to a successful aphid management program that relies on biocontrol. There are several biocontrol agents that attack aphids. Parasitic wasps (*Aphidius colemani* and *ervi*) and *Aphidoletes aphidimyza* (a fly with predatory maggots) work very well when applied preventatively for aphid suppression or when low numbers of aphids are first detected. It's important to remember that *Aphidius colemani* wasps attack green peach aphids whereas *Aphidius ervi* prefers potato and foxglove. These wasps lay eggs within the aphids and as they develop, they turn the aphid into a golden brown mummy (Fig. 2a). *Aphidoletes* (the fly) attack both aphid species and then some. *Aphidoletes* larvae can eat around 3 to 50 aphids per day for a week. Green lacewings (*Chrysoperla carnea*) and the convergent ladybird beetle (*Hippodamia* convergens) are two predators that are most effective when aphid populations are present. Establishing alyssum habitat plantings provide floral resources and encourage wild natural enemies to come inside tunnels. For example, many syrphid flies have maggots that attack aphids and other small pests (Fig. 3).

Fig. 3. Alyssum habitat planting (above). Syrphid fly maggot (below).

For well-established aphid populations with low evidence of natural enemies (i.e., maggots or mummies) and are causing damage, numerous insecticides are available. Some organic types include insecticidal soap, oils, azadirachtin and pyrethrin. Always read the label and remember that many are broad spectrum and can have adverse effects on pollinators and natural enemies. For more specific information on aphid management, refer to the New England Vegetable Management Guide (https://nevegetable.org/).

Tunnel Tomato Fertility: parts per million vs pounds per acre

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Soil-based high tunnel production combines hydroponic and field production techniques. Greenhouse technology drives yield and quality. This requires higher nutrient levels, which can mimic hydroponic production. However, our delivery must account for:

- Nutrient levels in the soil
- pH
- Temperature
- Organic matter
- Biology

Additional factors that influence our decisions on source and rates of nutrients include:

- Organic or conventional system
- Bulk (dry) or soluble materials
- Price
- Salt levels of soil and fertilizers

A common question then becomes how much supplemental nutrients to add? Should we take a quantitative (pounds per acre) or dilution (parts per million) approach? There are valid reasons for both approaches. Here we will use tomatoes and nitrogen to illustrate high tunnel soil fertilization practices.

- We need three tests to guide our decisions on high tunnel fertility: A standard soil test with a supplemental soluble salts test to determine nutrient status, organic matter, pH, and soil salt levels.
- An irrigation water suitability test that includes pH, alkalinity, EC (electrical conductivity) and TDS (total dissolved solids). Tests that include nutrient values will improve our interpretation.
- In-season foliar tests serve to cross check our nutrient management and allow for corrections.

Once we have these tests, we can make informed management decisions.

Pounds per Acre Calculations

Nitrogen is generally assumed to be a blank slate each spring. We know that organic matter makes significant contributions throughout the season, so these levels can be factored into a total nitrogen budget.

What is a nitrogen budget for a high tunnel tomato crop in the Northeast? A total nitrogen budget of 150 lbs/ac is a common recommendation, potentially more for high yielding crops, or less for high organic matter soils.

The next question we must ask is "will there be a preplant application"? Organic growers will often choose to apply some pre-plant nitrogen because organic nitrogen sources are often bulky and need to be incorporated and quick-availability. Soluble organic N sources are very expensive.

How much nitrogen should be applied pre-plant? We recommend no more than 50% of the total nitrogen budget, in this case 75 lbs/ac. This is to prevent excess levels at the wrong stage of crop growth. If too much nitrogen is mineralized too quickly, the crop can become excessively vegetative, delaying maturity and reducing yield.

Assuming that drip irrigation and an injector are in place, crop demand is now estimated and delivered on a weekly basis. Taking the remainder of the nitrogen budget, we can divide the amount of nitrogen desired by the anticipated number of weeks the crop will be in the ground.

For example, a high tunnel tomato crop transplanted on May 1 and terminated on October 1 would be fertilized for about 15 weeks. This is easy math: 150 lbs N/ac ÷15 weeks = 10 lbs N/ac per week. If you applied half up front, you need an additional5 lbs N/ac/week.

<u>How much fertilizer is needed to achieve this rate?</u>
We need a couple key values:

- Acreage of the high tunnel (square feet of tunnel growing area / 43560)
- % nitrogen in the fertilizer by weight (for both dry and liquid forms)

Divide the weekly desired rate by the % nitrogen in the product. For example, if we want 5 lbs N/ac and have 20-20-20 fertilizer, 5 / .20 = 25 lbs of fertilizer. Next, multiply by the acreage being fertilized. A high tunnel with 0.1 acres of growing space would need 2.5 lbs of 20-20-20 to deliver a weekly rate of 5 lbs actual N/ac. Finally, divide this rate by how many times you fertilize per week. Taking this lbs per acre approach we can strive for a uniform soil nitrogen status.

Parts per Million Nitrogen Calculations

Uniform soil nitrogen status is also the motivation for the parts per million (ppm) approach to high tunnel fertility. In this case we are borrowing knowledge from the hydroponic world where precise rates have been determined for tomatoes at various stages of growth. The major advantage of a ppm approach is a precision level application that allows us to get a proper ratio of nitrogen into the root zone, regardless of water demand. This contrasts with the lbs/ac approach that requires we apply sufficient water to safely deliver N. In heavy soils or cool, cloudy weather the crop may have a low water demand, but still need sufficient nitrogen. Applying a known ppm allows us to keep the crop fertilized properly during times of low water demand. Many sources suggest around 150 ppm pushing upward to 200 ppm N during peak

demand. To calculate how much fertilizer is required to achieve this rate we need several key values.

1. The proportional ratio of our injector. Many models are fixed at 1:100, and we'll use this ratio for ease of calculation.
2. Desired ppm N. 150 ppm is a safe figure.
3. The % N in our fertilizer.

Now we can use a simple formula to reach a weight of fertilizer to apply. Here we are solving for US ounces (by weight) and gallons of stock, the most common units amongst Northeast US high tunnel growers. Other units require different formulas. Our equation represents:
(ppm desired X injection ratio)/ (%N of fertilizer X 75) = ounces per gallon of stock solution.

For example, we desire 150 ppm N, our injector is set at 1:100 and our fertilizer is 20-20-20.
(150 X 100)/ (20 x 75)= 10 ounces of fertilizer per gallon of stock.

Now we can apply 150 ppm N regardless of how much water we irrigate by formulating our stock solution properly. More good news! There are many online calculators that will do this math for you, and even easier, greenhouse grade fertilizers will often have a simple chart to help achieve desired ppm for a known injection ratio and %N in the bag.

Parts per million helps us avoid over fertilization and elevated electrical conductivity levels in the soil. It is particularly useful for recently transplanted seedlings with low water demand. A ppm approach does not make sense for sandy soils that leach water quickly. In this case we are wasting and losing nitrogen if we continually irrigate at 150 ppm. The same comments apply to large crops during high temperatures. The combination of water and nutrient demand can push us back to the lbs/ac approach.

Conclusion

So, now that we know how to use these two approaches, which makes the most sense for high tunnels? Both have a role. Parts per million is particularly valuable early in the season, and the precision approach can be important when looking at nutrients besides nitrogen, that can easily be applied at toxic levels. The lbs/ac approach is useful in mid-season when both nitrogen and water demand is high. By understanding both approaches we can back-calculate how many lbs/ac N we are applying in a ppm approach and vice versa. This quick math can reduce over applications and compare our progress at meeting a total nitrogen budget for the crop year. Finally, foliar samples reveal sufficient (or excess) nitrogen levels in the living crop that require adjustments.

Tunnel Tweaks to Improve Tomato Yield

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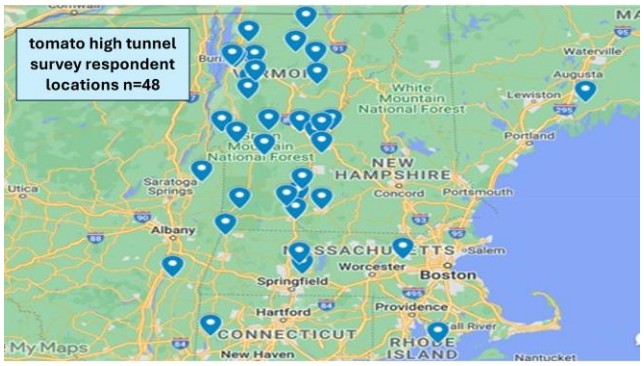
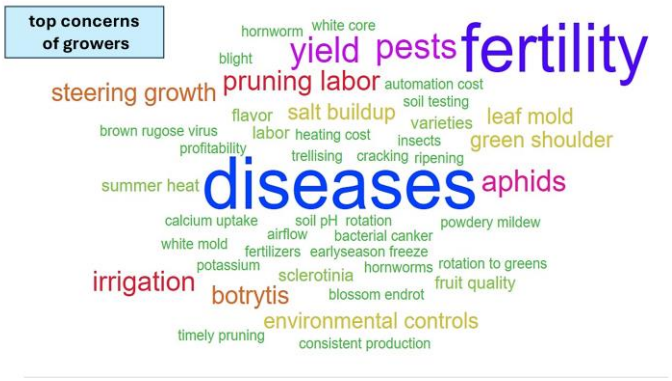
Many factors go into optimizing yield and quality of tunnel tomatoes. The appropriate level of investment in infrastructure and management time depends on a farmer's goals and capacity. Information about what one's peers are doing (aka benchmarking) can help growers understand their options for improving production in ways that fit their farm. However, there's not much data available about what constitutes "typical" practices.

In April 2024, ninety growers that had worked with UVM Extension on high tunnel tomato projects in the past were invited to complete a 37-question survey describing their infrastructure and management practices. Growers were asked to provide data from a tomato tunnel that had in-ground production of "slicer" varieties, drip irrigation, poly plastic covering, trellising with pruning to one or two stems, using conventional or organic methods that had been in production for at least three years. Forty-eight growers, primarily from Vermont but also from all other New England States plus eastern New York, completed the survey.



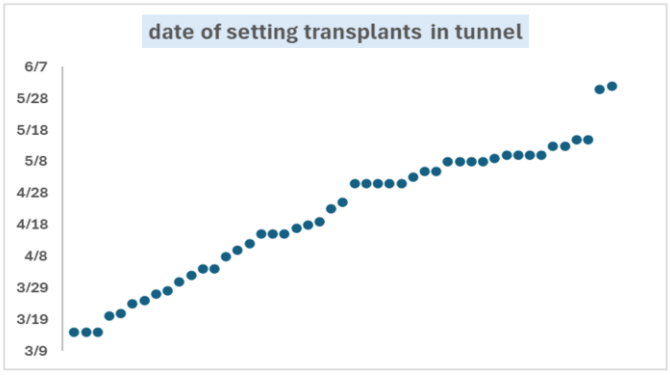
Here are some of the findings from the survey:

- 48% of the tunnels have been in tomato production for 10 or more years; 90% of farms follow organic practices; 71% are certified organic.
- 56% of the tunnels have never rotated out of tomatoes for a year; 75% of the tunnels are also used to grow winter greens.
- The top concerns cited about high tunnel tomato production were diseases and fertility, followed by pests, yields, and labor required for pruning and trellising.



- Geronimo is the most popular variety, followed by Rebelski, Big Dena, Big Beef, Caiman.

- 56% of farms use grafted plants; Maxifort is the most popular root stock, then DR0141TX.
- Farms use a variety of plant arrangements. About half the farms have a density of 4-6 sq. ft. per leader (stem), with some farms as low as 2 sq. ft. per leader and some as high as 9 sq. ft.
- 67% of farms do not lower their trellised plants; 19% lower them 3 times or more.
- 46% of farms do not thin their fruit clusters; 46% thin to 4 or 5 fruits per cluster.
- A variety of ventilation systems are used; 78% of tunnels have manual roll-up sides; 42% have endwall gable vents, 19% have ridge vents, 19% have automatic side vents.
- About half the tunnels have a passive ventilation opening area to tunnel floor area ratio below 0.35, suggesting that ventilation may be inadequate.
- 38% of tunnels lack Horizontal Air Flow (HAF) fans to keep air in the tunnel well-mixed.
- 48% of tunnels are unheated; 40% heat with propane or fuel oil; 15% have root-zone heat.
- About half the growers set transplants in late March or April and half set them in May.



- 63% of growers use the long-term high tunnel soil test to guide fertilizer applications and 19% also use leaf analysis; 67% use fertigation to apply nutrients; 21% use foliar fertilizers.
- A variety of surface mulches are used; 53% of tunnels have landscape fabric or black plastic mulch and 19% of tunnels are unmulched (bare soil).
- There is an average of one drip irrigation line per 2.2 ft. of tunnel width; the range is from one drip line per 0.9 ft. to one drip line per 5.0 ft. of tunnel width.
- Only 8% of tunnels use shade cloth; only 6% of tunnels have insect screening.
- 71% of growers use only passive pollination; 19% purchase bumble bee hives.
- 67% of growers use biological controls for insect pests; *Aphidius* and *Aphidoletes* are the most popular.
- 92% of growers apply sprays to control disease, primarily powdery mildew, gray mold, leaf mold, and bacterial diseases.
- 48% of growers do not know their yields; among those that have yield goals, 23% expect a yield of 2-3 lbs. per sq. ft and 23% expect a yield of 5-6 lbs. per sq. ft.
- 69% of growers have a retail price of $4-5 per lb. for tunnel tomatoes.

Actual yield in 2024 reported to date by 23 of the participating farms ranges from 0.74 lbs. per sq. ft. to 5.35 lbs. per sq. ft. of total fruit. The estimated percentage of seconds and culls ranged from 1% to 40% with an average of 22%. It appears that some high tunnel tomato growers have potential to significantly improve total yield and/or percentage of marketable fruit.

Here are some thoughts about the data above, and suggestions for potential improvements to tomato high tunnels:

A lot of growers don’t know what their yields are. It’s hard to measure the effect or value of changes/improvements if there is no baseline. Developing simple ways to track yields, like counting trays harvested, or weighing harvested fruit from a subset of plants, makes sense.

A lot of tunnels appear to be under-ventilated. Adding gable vents to endwalls, increasing the door size opening in endwalls, and adding ground post extension are options to add ventilation. Adequate ventilation is critical to avoiding high humidity and thus management of foliar diseases, which is a primary concern among growers.

Many tunnels do not have HAF fans. These are relatively low cost and if properly installed they help keep CO2, temperature, humidity evenly distributed in the tunnel.

Most tunnels do not have ground (root zone) heat. If planting in March or April when soil is cool, this could help promote early season growth and allow plants to size up sooner to utilize the maximum light period, which is in June.

Some tunnels have bare soil. Using mulches can help roots grow closer to the soil surface where oxygen and nutrients are likely more available.

About 1/3 of growers are not using the long-term high tunnel soil test, which is designed specifically for tunnel growing. Field soil tests are not as useful in guiding fertilization.

In tunnels with light-textured (sandy) soils, more drip lines may be needed to thoroughly wet the potential rooting area in a tunnel. Dry areas of the root zone can limit plant growth.
Some growers noted that they experienced unusually hot temperatures in their tunnel this past season. Timely use of shade cloth or whitewash may help address this concern and avoid associated reductions in fruit yield or quality.

11/1/23

Raspberry Weed Management

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Proper site and soil preparation for raspberries is critical for successful establishment of a new planting. Preventing weed problems in the planting year can 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 raspberries into recently plowed perennial grass sod. This can lead to devastating weed problems from species such as quack grass and clovers.

Tarping can 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. Planting following removal of the tarp should disturb the soil surface as little as possible to prevent bringing up more weed seeds.

Planting late in the spring as opposed an earlier planting date can be used to reduce weeds in a new raspberry bed. This “stale seedbed” strategy is effective against early germinating weeds. 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 weeds with light cultivation, a contact herbicide or flaming, and then plant. 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, dormant raspberry 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 produce primocanes (suckers) to fill out the bed. Increasing the in-row spacing a few inches (e.g. 12-16” between plants) can help increase the number of suckers in the planting year.

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 raspberries. Oats will winter kill, but rye will need to be crimped and rolled, 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 raspberry 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 likely be required within the plant rows.

Plastic mulches are also being used to reduce weed problems in raspberries. Planting raspberries through black plastic eliminates much of the weed pressure within the planting, but inhibits the emergence of primocanes to fill out the row. Specialized equipment for making beds and laying plastic mulch is required, but vegetable growers would likely have such equipment available. Cutting the plastic to allow the primocanes to emerge during the summer and/or removing the plastic completely is labor intensive, but having the plastic in place during early establishment to prevent the first flush of weeds may make it worthwhile. Biodegradable plastic mulches may also be applied at planting to reduce weed emergence. These products are more expensive than conventional plastic, but offer the advantage of breaking down in the field after two to four months, allowing the primocanes to emerge without having to remove the mulch.

Organic mulches, such as straw, woodchips and bark can also be used in the rows after planting to reduce weed seed germination. Apply a layer of mulch around the plants thick enough to prevent light from hitting the soil surface, about three to six inches thick. Wood chips and bark mulch can remain on the planting and may need to be replenished annually to retain its effectiveness. Straw mulch should be removed in the fall as it has been shown to encourage phytophthora root rot if left on over the winter and into the following spring. Once the plant population reaches the desired density, the canes can shade out most of the weeds in the plant row that would otherwise germinate, if early weed control efforts have prevented them from getting established.

If mulch is not used in the beds, emerging weeds can be managed with a variety of cultivation methods such as tine cultivators, disk cultivators, blind cultivators (e.g. Lely) and/or finger weeders (e.g. Buddingh, Regi). This can be effective early in the planting year, as long as it is combined with vigilant hand weeding within the plant rows, where the cultivators can't reach. Cultivation becomes more challenging later in the season and in following years when there are many suckers growing within the rows and sometimes into the aisles. Suckers emerging into the aisles outside of the recommended 18-24" row width should be eliminated to prevent the rows from becoming too wide and shading out the plants in the center. Generally, the need for hand weeding in a new planting will become more intense as the first season progresses. Flaming weed seedlings between the rows may be effective, but it is costly, and the burners must be well-shielded to prevent burning the raspberry plants. Flaming has the advantage of not disturbing the soil surface, and thus reduces further weed germination.

Herbicides can offer good control of many weeds in raspberries if applied under the appropriate conditions. However, the use of herbicides alone rarely gives complete weed control. Other strategies should always be in combination with herbicides to get the best control of all weed problems. Herbicides registered for raspberries and their applications are listed below.

1. Napropamide (Devrinol®): A pre-emergent herbicide that provides good control of annual grasses, volunteer grains and some broadleaf weeds. It is typically applied in the fall or early spring. Split applications have become popular due to the loss of other pre-emergent

herbicides, e.g. half maximum rate in late summer and a second half rate application once growth begins in the spring. Napropamide should be worked in by irrigation, rainfall or light cultivation within 24 hours of application.

2. Oryzalin (Surflan®): A pre-emergent herbicide that provides good control of annual grasses, and some broadleaf weeds. It is typically applied in the fall or early spring. should be worked in by irrigation, rainfall or light cultivation within 24 hours of application.

3. Simazine (Princep Caliber®): A pre-emergent herbicide that may be applied in the early spring before bud break and/or in the late fall after the canes have gone dormant. Often used in combination with Dervinol® or Surflan®. Will control broadleaf weeds and some grasses.

4. Terbacil (Sinbar®): A pre-emergent herbicide with some post-emergent activity, which should be applied in the early spring for control of broadleaf weeds and some grasses. A second application can be made in late fall, after the plants are dormant. Terbacil can cause plant injury. It is important to determine appropriate rates for each location.

5. Halosulfuron (Sandea®): A pre-emergent herbicide with post emergent activity on many broadleaf weeds and nutsedge. Applications must be made prior to primocane emergence in the spring. Avoid contact with canes to prevent chlorosis. A shielded sprayer is recommended.

6. Dichlobenil (Casoron®): A pre- and post-emergent herbicide for control of broadleaf weeds and some grasses. For use in the late fall when plants are dormant for control of weeds the following spring. Apply at temperatures below 40°F.

7. Sethoxydim (Poast®): A post-emergent herbicide for control of actively growing grasses. It will not control broadleaf weeds. It should not be applied when grasses are under stress, e.g. drought, or on unusually hot, humid days. Do not use sethoxydim within 6 weeks of terbacil (Sinbar®) applications, to avoid leaf injury. Sethoxydim should be used in combination with a crop oil concentrate. A second application may be needed to control some perennial grasses. Do not apply within 45 days of harvest.

8. Clethodim (Select®): A post-emergent herbicide, similar in activity to Poast®, for control of actively growing grasses. It will not control broadleaf weeds. It should not be applied when grasses are under stress, e.g. drought, or on unusually hot, humid days. Clethodim should be used in combination with a crop oil concentrate.

Always read and follow all product label information and precautions. Where brand names are used it is for the reader's information. No endorsement is implied nor is any discrimination intended against products with similar ingredients. Users of these products assume all associated risks.

Growing Blackberry Production and Sales in Missouri

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Blackberries are a viable commercial fruit crop for farmers in Missouri and other states in the Midwestern region of the United States. Recent advances in blackberry cultivar development and production practices have greatly enhanced the profit potential of this crop for farmers, and several markets (on farm sales, farmers markets, wholesale markets, and institutional markets) are clamoring for locally grown blackberries.

A blackberry planting was established at the University of Missouri Southwest Research Center (SWRC) in Mount Vernon, Missouri, USA in March 2016. Funding for the project was provided by a MDA Specialty Crop Block Grant. The planting highlights recent blackberry cultivar and production technology developments and is a powerful demonstration site for adult learning. The planting features:

- Seven thornless blackberry cultivars ('Natchez', 'Osage', 'Ouachita', 'Apache', 'Triple Crown', 'Prime-Ark® Freedom', 'Prime-Ark® Traveler') planted in 2016 in a completely randomized design, with three replications of each cultivar and three plants per replication. We collected data on fruit yield, fruit size, and ripening time in 2017 and 2018; the data highlight the potential of these cultivars for profitable production in Missouri.
- The rotating cross arm (RCA) trellis, an innovative trellis design that allows farmers to change the orientation of the blackberry plant and overcome several factors that that limit blackberry profitability in Missouri. The trellis design allows farmers to concentrate the berry crop on the shady side of a supported canopy that effectively divides the floricanes from the primocanes. The trellis allows farmers to protect plants from winter conditions with rowcovers, reduce fruit loss from sunscald, and improve pest management and harvest efficiency. Details on the design and use of the RCA trellis are found at https://web.extension.illinois.edu/mms/downloads/47252.pdf
- Innovative production practices, including the use of tissue culture plug plants, raised beds, drip irrigation, spotted wing drosophila (SWD) trapping, weed barrier fabric mulch for weed control, and floating row cover for winter protection.

The planting consists of 3 rows that are 12 feet apart, oriented east to west. Plants are planted 5 feet apart in plots of 3 plants per cultivar, with 3 plots per cultivar in the planting. The plants are on raised beds that are 36" wide and 8" high. We covered the beds with woven landscape fabric, and placed a single 18mm dripline per row, with 18" emitter spacing. We followed standard cultural practices with regard to preplant soil testing and soil modification, planting establishment, pest management, and weed management between rows (which were in sod). The planting was fertigated weekly from April to September, for an equivalent of 80 total lbs/acre of nitrogen per growing season.

The RCA trellis system offers huge benefits as described above, but we learned that timely management is critical to see these benefits. We carried out the following practices:

Mid March: remove the floating row covers; apply delayed dormant lime sulfur fungicide, raise and then lower the trellis to mow as needed.
Late April: raise the trellis from the horizontal position to the fruiting position as soon as the flower clusters have a fixed upright position. Don't delay, or the primocanes will have too much upright growth and will be difficult to tie into the horizontal position.
Late April through May: immediately begin tying the early emerging primocanes to the horizontal position along the training wire on the primocane side of the trellis. Use rubber bands, and handle primocanes gently as they are brittle. A minimum of 3 strong primocanes are needed; consider tying 1-2 extra primocanes. Tie primocanes at least twice a week until the primocanes reach the neighboring plant, then tip the primocanes. Primocane training will conclude in early June.
June through August: fruit harvest. Trap for SWD, and apply protective sprays as needed.
August through September: promptly remove floricanes as harvest ends. Tie primocane laterals into position on the fruiting side of the trellis. Space laterals 6" apart.
Late November through early December: rotate the trellis to the horizontal position for the winter, and cover the plants with protective rowcover.

Results from the 2017 harvest season
The demonstration blackberry planting at SWRC, including the seven thornless blackberry cultivars trained to the RCA trellis, produced an initial, significant fruit crop in 2017, just one year after establishment. Data collected on the 2017 fruit yield, fruit size, and harvest season are presented in Table 1 and Figure 1. Floricane harvest began on June 9 ('Natchez', 'Prime-Ark® Traveler') and continued through August 1 ('Apache'). Primocane harvest commenced on July 26 and continued through October 6 for both 'Prime-Ark® Traveler' and 'Prime-Ark® Freedom'. Impressive first year floricane yields were noted for 'Natchez', 'Ouachita', and 'Prime-Ark® Traveler'. 'Apache' and 'Prime-Ark® Freedom' produced the largest floricane berries. First year primocane yields were modest for both 'Prime-Ark® Traveler' and 'Prime-Ark® Freedom', though the berry size of 'Prime-Ark® Freedom' was impressive. Figure 2 illustrates a peak volume of floricane berries produced among the cultivars in early July, followed by a second peak (though of less volume) in early August. A peak in volume of primocane berries was noted in late September. Worth noting is that while 'Prime-Ark® Traveler' produced berries that were smaller than several cultivars, it produced a continual summer-long harvest (June 9 to October 6), with floricane and primocane fruit production overlapping, resulting in season-long fruit yields that were the highest among all cultivars.

Results from the 2018 harvest season
Data collected on the 2018 fruit yield, fruit size, and harvest season are presented in Table 1, and represent what we would consider to be a full crop. The sequence of ripening and the length of season were similar to 2017 (dates not shown). We noted impressive floricane yields for 'Natchez', 'Osage', 'Triple Crown', and 'Prime-Ark® Traveler'. As in 2017, 'Apache' and 'Prime-Ark® Freedom' produced the largest floricane berries. 2018 primocane yields were disappointing for both 'Prime-Ark® Traveler' and 'Prime-Ark® Freedom', and data were not collected.

Discussion

The RCA trellis requires a lot of attention from a management standpoint, and practices must be done in a timely fashion. In particular, training the primocanes to the horizontal position must be done when the shoots are small and flexible. We also strive to remove the floricanes as soon as possible after harvest, and transfer the primocane laterals to the fruiting side of the trellis. Among the cultivars under trial, 'Natchez' and 'Triple Crown' have a growth habit that works well with the RCA system. Based on two years' harvest information, 'Natchez', 'Prime-Ark® Traveler', and 'Triple Crown' would be good choices for Missouri blackberry farmers. Other challenges noted during the trial include management of SWD and Japanese beetle. Our experience with the primocane crop has been disappointing. Additional information on the study is available from the author. Recent developments in RCA trellis management from the University of Arkansas are available at https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/horticulture/commercial-fruit-production/rca-trellis-blackberry.aspx . In particular, the primocane fan training method simplifies primocane management. Several recently released University of Arkansas blackberry cultivars, including Caddo and Ponca, are of interest for Missouri blackberry producers, though these cultivars have not been extensively tested in Missouri.

Table 1. Floricane yield and berry size for 7 thornless blackberry cultivars, 2017 and 2018.

Cultivar	2017 Yield (lbs/plant)	2017 Berry Size (g)	2018 Yield (lbs/plant)	2018 Berry Size (g)
Prime-Ark® Freedom	1.03 e*	8.8 a	7.72 d	7.3 a
Prime-Ark® Traveler	14.72 ab	4.9 e	17.25 ab	4.0 c
Apache	9.50 d	8.1 b	10.63 cd	6.4 ab
Natchez	16.76 a	7.4 c	20.28 a	6.2 b
Osage	10.34 cd	5.1 e	15.62 abc	4.7 c
Ouachita	13.64 abc	6.2 d	12.17 bcd	4.5 c
Triple Crown	11.37 bcd	4.6 e	20.31 a	4.0 c

* Means within columns with the same letters are not different according to Fisher's Least Significant Difference test ($P < 0.05$).

Figure 1. Harvest dates for 7 thornless blackberry cultivars, 2017.

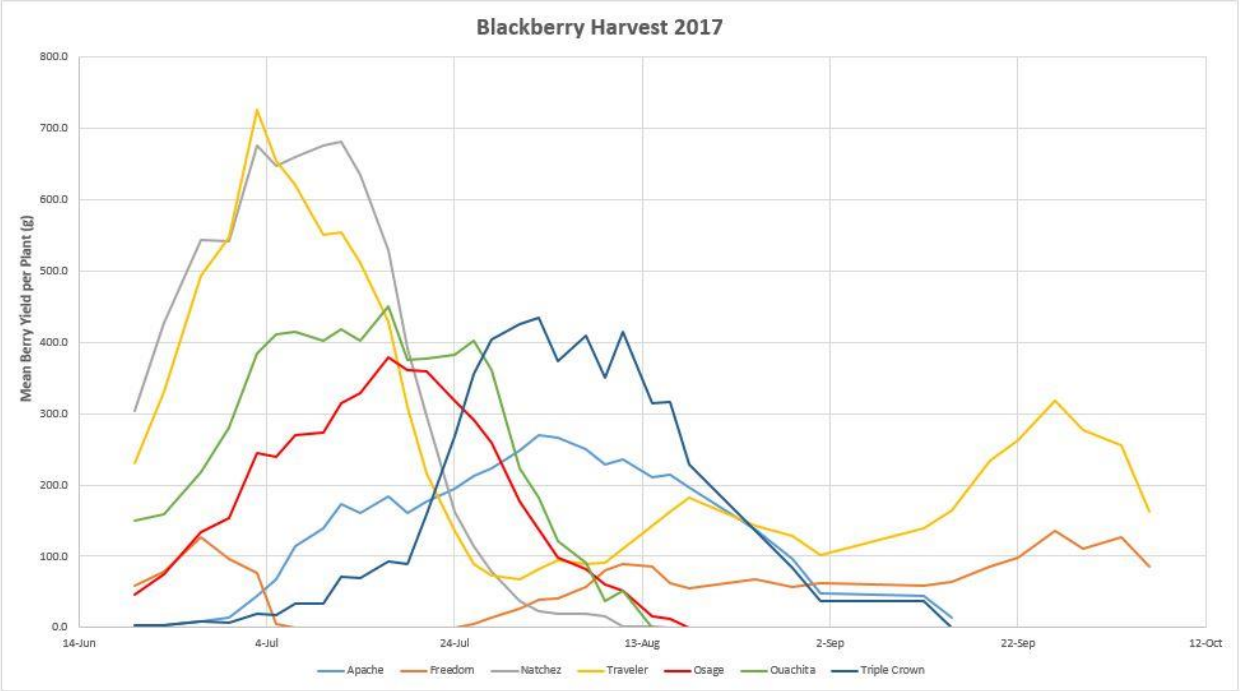

Figure 2. RCA trellis, showing the fruiting arm with floricanes in the fruiting position (right) and a trellis in the winter position (left).

Emerging Technologies for Weed Control in Tree and Vine Crops

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Tree fruits, tree nuts, grapes, and berries are vital to local and regional agricultural economies. According to the 2017 USDA Census of Agriculture, perennial fruit and nut crops are cultivated on 6 million acres across 110,000 farms, with the industry valued at approximately $29 billion. Grapes, including those for wine, juice, raisins, and table consumption, represent the highest-value fruit crop in the U.S. at an estimated $5 billion, followed by apples at $3.2 billion. About 50,000 farms cultivate these crops on 1.4 million acres nationwide. Additionally, the production of almonds, walnuts, hazelnuts, pecans, and pistachios spans over 2 million acres, primarily in the Western and Southern states, valued at $9 billion. Berries, including cranberries, contribute another $1 billion, with major production centers in the Western, Southern, Great Lakes, and Atlantic Coast regions.

Weeds pose a significant threat to fruit and nut crops, particularly during the establishment phase, where competition can hinder stand development and delay fruit production. They can also provide shelter for vertebrate pests, such as voles and gophers, which may damage roots and trunks. Additionally, weeds may serve as alternative hosts for harmful insects and pathogens. For example, the X-disease phytoplasma, detrimental to cherries, can survive on common orchard weeds like mallow and dandelions, as well as its leafhopper vector. Weeds can affect fruit and nut quality; for instance, weed seeds may contaminate raisins during drying. Unwanted vegetation can interfere with crop management practices, complicate harvest operations, and increase labor costs. In arid regions, weed competition may raise crop water demands, while dried weeds can pose fire hazards.

To maintain yields, many fruit and nut growers rely on herbicides for weed control. However, this practice has downsides. The evolution of resistance in weed species—112 cases reported in blueberries, grapes, and orchard crops—along with the risk of crop injury from postemergence herbicides and worker safety concerns related to toxic products like paraquat deter some growers. Non-harmonized pesticide residue limits between the U.S. and key export markets may create trade barriers, influencing weed control decisions. Regulatory challenges tied to the EPA's workplan under the Endangered Species Act could impact the registration and reregistration of pesticides, which are already limited in fruit and nut crops. Other weed control methods face constraints as well. Cultivation can harm shallow-rooted fruit crops, promote erosion, and negatively affect soil structure and organic matter. Moreover, it is not feasible for some hilled berry crops, like blueberries, or in rocky soils. While plastic mulches have limited utility and lifespan, hand-weeding is increasingly threatened by rising labor costs, an aging workforce, and uncertain immigration policies, underscoring the critical yet diminishing role of migrant labor in pest management.

Given the challenges of current weed management practices in perennial crops, many growers and industry professionals are seeking alternative methods to control unwanted vegetation. In

2021 and 2022, project team members surveyed over 300 fruit and nut stakeholders nationwide to assess their interest in innovative weed control technologies. Respondents represented a variety of crops, including almonds, walnuts, blueberries, apples, grapes, and stone fruits, and varied in farm size from less than 10 to over 1,000 production acres. Seventy-one percent of respondents reported relying on herbicides for weed control, while 45% also used hand weeding and 32% utilized cultivation. Between 40% and 50% expressed interest in exploring electrical weeding and precision, vision-guided sprayers and cultivators, along with other novel tools. Over 70% identified performance and the safety of crops and workers as the main factors influencing technology adoption. Additionally, 60% to 70% of respondents considered cost and environmental impacts—such as protecting soil and pollinator health—important when evaluating new tools.

Research into optically guided spraying and electrical weeding has been conducted in New York (NY) and New Jersey (NJ). Targeted herbicide applications are of interest for their projected abilities to reduce herbicide use and crop injury risk, support the evaluation of new herbicides because of enhanced crop safety, and serve as a mitigation strategy for preventing off-target herbicide movement that could negatively impact threatened and endangered species. In our studies, optical sprayer treatments were made using a Weed-It Quadro system (AgriTech America) equipped with 4 sensor-nozzle (TG-3) units conveyed on a Polaris ATV driven at 5 mph. Unlike the backpack sprayer, which delivered a continuous application of product to the treated area, the Weed-It sprayer nozzles were only actuated (e.g., turned on) when an affiliated sensor detected a chlorophyll signal. Results from trials in Seyval grapes in NY indicate that precision, optically guided spray technology can significantly reduce weed cover compared to untreated check plots. The effectiveness of this technology in achieving comparable weed control to conventional banded treatments appears to depend on the level of weed pressure at the time of application. Under our study conditions, the vision-guided system was less effective than continuous banded applications when weed cover reached approximately 50%. However, both methods performed equally well at controlling weeds when the initial cover was around 20%. Regarding crop injury, significantly less canopy damage was observed when herbicides were applied using the optically guided system compared to continuous banded treatments. In NJ blueberries, crop injury was higher using the optically guided system as it detected new cane grow as well as unwanted weedy vegetation.

Electrical weed control (EWC) is a non-selective method that eliminates plants by passing an electrical current through them, generating heat that disrupts cell membranes, reduces growth, and ultimately causes plant death. For our research, we utilize a tractor-mounted system produced by Zasso™. This unit features a step-up transformer that increases the voltage generated by the PTO-driven motor. The electrical current is directed to front-mounted applicators equipped with electrodes. The current is applied when the electrodes contact a plant or the soil. Although EWC equipment is commercially available, there is still much to understand about how electrical weeding can integrate with existing weed management strategies and its effects on the soil environment. Results from trials in NY EWC can effectively reduce perennial weed cover and biomass in organic orchard systems, particularly when applications were followed by cultivation. Studies to describe impacts on soil microbial respiration and soil microarthropod density and diversity are ongoing.

Precision Apple Cropload MANagement (PACMAN): Optimizing profitability by optimizing apple crop load (but maybe it is not for everyone)

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Controlling the final fruit number on an apple tree is one of the most economically critical management practices in apple growing. Optimizing fruit numbers within a narrow, economically optimum range is currently imprecisely done by pruning, chemical thinning and remedial hand thinning which is very expensive. Our previous work has shown that precisely controlling crop load has large economic benefits. We have previously developed ideas and tactics to precisely control crop load by calculating the optimum fruit number per tree, manually counting buds, flowers and fruits and by using various computer models we have developed (carbon balance model, fruit growth rate model and the pollen tube growth model) to help growers achieve the optimum number of fruits per tree; however, the process is tedious and time consuming. Through this project we will further develop precision crop load management tools consisting of computer models, machine vision, robotics and decision support tools to which will allow apple growers to accurately calculate a target fruit number for each tree and then quickly count flower buds and later fruitlets using machine vision and geo-referenced maps to guide the severity of pruning and later guide bloom and post-bloom chemical thinning, and lastly to guide human workers when hand thinning to maximize crop value. https://pacman.extension.org/

Precision Apple Cropload MANagement (PACMAN) steps include:

- Precision pruning
- Precision chemical thinning
- Hand thinning
- Result – achieve optimum economic crop load
- Most typically applies to tall-spindle system and higher value varieties (Honeycrisp, Gala, Fuji)

Precision pruning

Reduces number of flower buds to predetermined number using tall-spindle pruning rules and spur extinction (Robinson, et al., 2013. New York Fruit Quarterly, Volume 21, Number 2, Summer 2013.)

- 1 bud per final fruit number? – risky
- 1.5 to 2 buds per final fruit number? – yes
- 3+ buds per final fruit number – risk overcropping and biennial bearing
- 1.5 to 2 buds
- Tall-spindle rules; bud extinction
- Example: Honeycrisp, 80 apples per tree target, leave 120 to 160 buds (but not w/o caveat)

Ah, but there is a catch! Honeycrisp: identifying floral vs. non-floral buds? We have a fact sheet for you! HRT-Precision crop load management of Honeycrisp: flower bud identification and precision pruning, https://ag.umass.edu/fruit/fact-sheets/hrt-precision-crop-load-management-of-honeycrisp-flower-bud-identification-precision-pruning

Precision chemical thinning

- Start with the Pollen Tube Growth Model (PTGM) on NEWA
- Then note the carbon balance model (also on NEWA)
- Implement the fruit growth rate model

Pollen tube growth model (PTGM)

- Note date of king bloom
- Measure style length
- Apply caustic thinner (ATS or lime sulfur) when NEWA PTGM model shows king flowers have been pollinated

Carbon balance model

- Apple carbohydrate thinning model on NEWA
- Timing and rate adjustment of chemical thinner
- Solar radiation and temperature dependent
    - More light = more difficult to thin
    - Higher temperature (particularly at night) = easier to thin

Fruitlet growth rate model

- Tag trees and mark clusters (5 x 14 = 70)
- Count flower clusters
- Begin measuring fruitlets at 6-7 mm
- Measure at 4-5 day intervals post chemical thinner application
- Number of apples per tree and % set
- Full directions here: https://ag.umass.edu/fruit/fact-sheets/hrt-recipe-predicting-fruit-set-using-fruitlet-growth-rate-model
- Malusim and Fruit Growth Model (Ferri FGM) apps for use in field are available in respective app stores (iOS and Android)

Fruitlet size distribution model (FSDM)

"A new approach, termed the 'Fruitlet Size Distribution (FSD) Model', described herein, was developed to produce predictions of apple fruit set comparable to the FGR model but achievable with less time investment. The principle underlying both models is the same: the relative growth rate or size of a fruitlet is compared to the most rapidly growing or largest fruitlet within the sample date to determine if it will abscise." https://pacman.extension.org/2024/03/28/the-fruitlet-size-distribution-fsd-model-a-how-to-guide-2024-update/

Hand thinning

Hopefully minimal as a last resort to get the final crop apple load right at harvest for optimum profitability in fruit sizes and promoting annual return bloom! Be sure to know your target apple number per tree!

My experience with Outfield and Vivid-Machines in 2024:

Outfield - UAV based mapping of orchard blossom density, crop load management, and yield forecasting. Get a drone. Fly your drone. Receive data. Take actions such as variable rate spraying for blossom thinning or directing hand thinning crew where the fruit set is highest. https://outfield.xyz/

Vivid-machines.com
"Fast and easy data collection from blossom to harvest for precision crop load management, providing valuable insights for growers, packhouses, and marketers. The Vivid X Vision System mounts onto any farm equipment and provides real time data and predictions for every plant." https://www.vivid-machines.com/

But what are the hang-ups?

- Time and complexity
- Many blocks/varieties
- You can't image what you can't see
    - Occlusion
    - Fruitlets
    - 2-D canopies
- Yield estimation and size distribution at harvest
- Cost
- Actionable?

Orchard Protection in Modern Agriculture

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In the last few years, our life has changed and the way to farming changed too. Today's fruit farming presents itself as a challenge, where fruit growers have to deal with several complex and often unpredictable issues: the global and integrated market that has raised the level of competitiveness, geopolitical issues that lead to sudden effects such inflation, mutable prices, uncertain revenues and, above all, climate change.

It is undeniable that climate change is responsabile of several new problems also in areas formerly not affected by them: the invasion of insects, some of which are so far unknown, extreme climatic and atmospheric events such as hailstorms, heatwaves, strong sun and wind, all variables that make cultivation a truly heroic undertaking, especially if it is done “under the sky” without any covering protection able to mitigate such harmful events.

Further, faming today means taking care about a lot of decisive aspects not always considered in the past but became essential to get a successful business, such as paying more attention in terms of soil preparation, parcels layout to optimize production, logistic and manpower, fruit trees quality and varieties, irrigation and fertigation, up-to-date and farsighted agronomic consulting, mechanization, adequate supporting trees systems and active crops defence.

The question is, “how long does it take to acquire new needful habits in farming? And the first answer is “Certainly not when it will be too late by then”.

In this context, to guarantee steady high-quality fruit production, it is essential to put in action a resolutive defense able to keep an ideal microclimate within the orchard so as to meet the demands of the customers, often large supermarket chains with increasingly high-quality standards and expectations. Indeed, the loss of customers has become a real threat for those who cannot meet these challenges.

Every grower knows that, to minimize risks, every single step has to be properly done and among a lot of proposals, he has to choose the more practical, effective and innovative ones, always taking into account the matter of the quality, aiming the faster return on investment and wisely considering the “total cost of the ownership”.

Nowadays, there are customized solutions capable of completely and comprehensively solving all orchard problems in an active way, stable and long-lasting systems made up of structures that use the nowadays deeply tested and high-performant technology. These tensile structures consisting of concrete pre-stressed posts, connected each other by high strength and low elongation ratio steel wires and ropes, held in tension by special anchors driven into the ground. The structure allows the entire system to be highly flexible and resistant even to severe weather

phenomena. A set of meticulously designed metal and plastic accessories completes the systems allowing them to be quickly installed and easily put in maintenance. Finally, a multi-functional netting covering is laid on top of it, serving simultaneously for various purposes: by covering the rows entirely, in fact, it can protect orchards against hail, wind, sun, insects, insects, birds, animals, trees and fruits diseases, besides creating a special microclimate within the orchard that is favorable to fruit cultivation.

Valente has been designing and manufacturing complete technical solutions for orchards since more than 60 years. Present in 74 countries, it acts as a strategic partner for fruit growers, offering complete multi-functional solutions studied using an engineering static calculation approach, designed to be stable and safety, able to help them addressing today's and tomorrow increasingly more complex issues. With this innovative and sustainable approach, Valente is able to predict and solve the difficulties in farming, already massively present in different areas of the world, helping farmers to thrive. Thanks to these forward-looking, versatile, reliable, and long-lasting solutions, fruit growers can not only keep their businesses safe and prosperous, but also contribute to a more sustainable and resilient future.

Small Scale Cover Cropping for Reduced Tillage Systems

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Little River farm is 3 acres of permanent vegetable beds in Exeter, RI. Currently, we sell at the Newport, RI farmers' market, through a small CSA and two local food hubs. The farm is three narrow fields along the pristine Queens River surrounded by mixed white pine forest. For the generally mild RI climate we are in a bit of a frost pocket, and quite shady. Cover crops have been a key part of production at Little River Farm since its inception in 2013. Cover crops and reduced tillage as part of vegetable production are keys to achieving both ecological and production goals.

In this presentation I will share my process for growing cover crops, from bed preparation through termination. The following are my goals for cover cropping on the farm:

- Keep the fields green
- Extend rotation with non-crop plants and fieldwork
- Diversify non-crop flora in field
- Maintain blossoms on farm for pollinators,
- Increase structure in fields to slow wind and provide habitat
- Reduce weed pressure
- Have fun through experimentation

Cover crop establishment

Most cover crops are sown with a 42" Gandy drop spreader and incorporated with a customized shallow rototiller/bed roller. Occasionally, a Jang seeder is used to seed small-seeded cover crops or for wider row-spacing. We presently are trialing putting 1/2"" compost over seeds as an alternative to incorporation.

Species selection

I mostly seed cover crop cocktails based on what is on-hand at the farm at a given time. Species have included:

- Broadleaves: buckwheat, sunflower, vetch, field pea, winter pea, crimson clover, phacelia, daikon radish, cowpea, soybean, flax, mustard
- Grasses: Cereal rye, annual rye, sorghum Sudan grass, Japanese millet, finger millet, oats

In my rotation winter rye is the most important cover crop, as it grows when very few vegetables do. We use rye as part of two cover crop systems, a roll crimped rye, and an early tarp-terminated rye. The second most important cover crop on the farm is buckwheat, which is used

during spring fallow periods. A small amount of winter kill cover crops are grown on the farm. These include sorghum sudan grass, oats and peas.

Termination methods

The roller crimped rye is rolled, using a disengaged flail mower, the first or second week in June shortly after the rye flowers. Following this, I tarp the rye for 1-2 weeks, and then plant through the mulch. Fertilizer is broadcast applied, but not incorporated. For the early tarp-terminated rye I mow it down, spread and incorporate amendments for planting, including compost, and tarp for 2 weeks. During the spring we fallow fields using buckwheat. This cover crop, established during May, is mowed amended and tarped in June during its first week of blossom. Staggered plantings through the month allow for a longer blossom window. Winter kill cover crops typically grow at the same time as a lot of vegetables, so I only do a limited amount. Examples include a spring sown mix of Sorghum Sudan grass in a few beds I'll be transitioning to perennials and early August we seed oats/peas and daikon in alternating rows, and two weeks later under sow with crimson clover. I also under seed fall brassicas with crimson clover during the final cultivation. Legumes are easily terminated during flowering by mowing, amending and tarping.

On-going experimentation

This year I was able to trial a few novel cover crop ideas. In the spring I sowed a cocktail of buckwheat, Sudan grass, and cowpeas. The buckwheat completely took over. For the second seeding I roll crimped the buckwheat at flowering to let the Sudan grass and beans grow through. It worked very well, and I will try that on more beds next spring. End of September I seeded a row of annual rye grass in the pathways of late season/ overwintered crops. The jury is still out on whether I will do more of that or not. A combination that I recently learned from is flint corn with hairy vetch under sown. I was unable to get the beds prepared for laying plastic mulch before August.

Ridges, mulches, tarps, cover crops, and compost: tapping into a wide toolbox for growing soil fertility and production efficiency on a vegetable farm

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Evening Song Farm is a certified organic vegetable farm in Shrewsbury VT, growing intensively on 4 acres since 2012 for a CSA and local wholesale accounts in March-December. The land here has a 5-8% southwest slope, and the soil is somewhat rocky silty loam on top of deep heavily compacted glacial till subsoil.

We employ a range of production techniques, and those methods are geared primarily towards increasing and maintaining the fertility of the soil, and secondarily towards efficient and profitable production systems. Our markets allow us enough margin on our cost of production to give us the flexibility to prioritize long-term soil fertility while also generating enough profit to live comfortably, make investments on our farm, and retain employees for several years.

Because my understanding of soil fertility has changed over time, here is a more specific description of what we are striving for our growing practices to achieve: The soil would be covered in organic material in different stages of decomposition, and when brushed aside the mineral soil is composed of many different sizes of dark crumbles, without any finely pulverized particles. A variety of insects and arthropods can be seen under the mulch. Digging into the soil reveals root systems of previous plants decomposing, and a garden fork can be pushed in deeply with little resistance. The soil infiltrates water rapidly during heavy rain, and any water that does run over the surface is clear. An intense rainfall does not result in the formation of rills, nor does the splash of raindrops separate and sort soil particles, and the soil surface retains its loose crumbly structure after heavy rain. The soil is growing few perennial weeds and there are few annual weeds that germinate through the growing season. Crops rarely need to be irrigated after establishment because after excess water drains through the soil, there is little evaporative loss from the soil. Crops grow well with little fertilizer inputs other than compost and have minimal need for intervention to manage pests and diseases.

Our farm uses the following practices to try to get closer to achieving these soil fertility goals:

- **Grassy swales maintained between 40 ft wide production fields.** Swales run across the slope of our fields and divert surface runoff off of fields into a ditch lined with willows. Before setting up these swales, runoff previously had the opportunity to erode significant rills down the long slope of our field.
- **Permanent tire tracks on our fields**. Limiting tire traffic in between permanent beds allows us to subsoil and chisel plow beds without re-compacting loosened soil with machinery.
- **No-till production on cover crop residue.** High residue cover crops (rye, yellow blossom sweet clover) are grown to the flowering stage before being mowed or flattened and then tarped. These fields are no-till transplanted to fall brassicas (broccoli, kale,

cabbage, brussels sprouts) which grow in the undisturbed root system of the cover crop, through the dead cover crop residue. Growing crops in this way convinced me of the value of planting crops into soil already structured by an extensive cover crop root system, undisturbed by tillage. This method is also rewarding in its ability to suppress annual weeds and maintain good soil moisture for a crop through dry spells. No-till planting through Yellow Blossom Sweet Clover residue has been exceptional at providing steady nitrogen availability for the following crop even through intensely wet weather that made nutrient management difficult on other fields.

- **Using coulters to prepare soil for transplanting**. To transplant into tarped cover crop debris, we cut slits into the soil using a toolbar mounted with fluted coulters. This cuts narrow slits that are satisfactory to transplant into. This technique also works well for planting a summer transplanted crop in a space where a fast early spring crop was mowed and tarped. It avoids more aggressive bed preparation that would otherwise pulverize soil aggregates and stimulate weed seeds to germinate.
- **Mulching with hardwood bark.** Our farm has access to affordable shredded hardwood bark from a local mill. This bark is applied about 2" thick as a mulch over most transplanted crops, with benefits in weed suppression, water infiltration, soil organic matter content, and overall crop vitality. This bark has a high C:N ratio and does have the ability to tie up nitrogen and stunt crop growth, but crops respond well to top-dressing with pelletized poultry manure fertilizer after mulching. The finely shredded mulch has the benefit of being able to germinate clover seed if it is broadcast on top of the mulch before rain.
- **Mulching with compost.** While many farms our scale and smaller successfully utilize finished compost as a weed-suppressing mulch, our farm does not have access to compost at a price that can justify applying it so liberally. Instead, our farm makes compost from hardwood bark with poultry manure, crop residues and weeds, and some soil to make a weed-free compost with a fairly high C:N ratio. We apply this compost in bands on ridges rather than across the entire surface of a bed in order to use the material more judiciously, and can direct seed or transplant into it. Because of the high C:N ratio of this compost, like the hardwood bark mulch, it requires some topdressing to avoid N deficiency but then grows beautiful and healthy crops.
- **Growing crops in ridges**. On some of our fields, after subsoiling and chisel plowing to thoroughly loosen subsoil, two ridges per bed are raised with hilling discs. The valleys and sides of the ridges are immediately mulched with bark, and the ridge tops are mulched with either bark or compost. We've found several advantages to growing on ridges: weed control in the wide space between the ridge tops is easily maintained by heavy mulch application, crops grow in exceptionally friable soil (carrots can be harvested without forking or undercutting), crop canopies enjoy good airflow between ridges, and heavy cover crops grown in ridges can be easily managed by mowing and raking residue into the valleys before planting a subsequent cash crop. I'm also inclined to believe that the soil microbiology may be able to more effectively cycle nutrients as a result of improved air exchange in the soil. Crops that we normally plant in rows one-foot apart (onions, leeks, garlic, beets) can be planted two-rows per ridge: slightly closer spacing between the rows, but with generous canopy space the outer edges. By facilitating weed management through heavy mulch and keeping soil uncompacted, it is

easy for us to use ridged fields to grow cash and cover crops for several years without the need for tillage.

- **Transplanting into Dutch White Clover sod**. Learning from Sawyer Farm, our farm has begun transplanting crops into living Dutch White Clover sod without tillage. We mow the clover and apply bands of finished compost about 2" thick and 8" wide, into which brussels sprouts and storage cabbage are planted. The compost suppresses growth of the clover in the band, and allows the brassica crops to outgrow the clover in the pathways, which does not grow taller than 12" high. The clover strips are mowed once or twice after transplanting. This method grew excellent fall brassicas but only satisfactory summer squash and peppers. It also does allow for annual and perennial weeds to remain hidden in the clover, and those fields will eventually require some tillage to reset the annual and perennial weed seedbank.

As we have gradually developed the techniques that we use to try to improve the productive capacity of our soil, we've enjoyed some additional benefits. The first is that managing our farm is now less stressful for me than it was in the earlier years when our production methods were slowly degrading soil fertility. I feel much more in alignment with my goal of good land stewardship than in earlier years when we sold beautiful and abundant vegetables, but also saw our soil structure degrade over time and watched brown water wash off of our fields in heavy rain. Work also tends to be more enjoyable for our crew, who feel positive about the changes in our production practices.

All of these practices have been designed for the particular details of our own farm, and all of them have been adapted from other farms' growing practices. These particular growing methods are well suited for the context of our own farm, but of course might not be applicable or might need some modification to fit other farms' contexts. As in all things agricultural, the details matter, so feel free to reach out if you have any questions about modifying any of these practices to your own operation. I hope that sharing our own experience might spark some creativity in visioning what it might look like to improve the fertility of your farm's soil.

Scaling Up Organic No-Till Potatoes

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Potato production involves a great deal of tillage and bare soil with the associated risk of soil erosion, nutrient loss and decline in soil health. The purpose of this trial was to demonstrate a strategy for growing no-till potatoes that achieved good weed control, reasonable yields and used machinery that would allow for scaling up.

Most of the fertility for the potato crop was applied before planting a rye cover crop in September the year previous. It is important to use good quality seed at a high rate [120 lb/ac] as the rye biomass growing the next spring needs to provide enough biomass when mowed to control weeds through the potato growing season and to prevent greening of tubers near the surface.

The potatoes are planted into the standing rye about 3 weeks prior to late rye bloom. This timing requires potato planting at the end of April to the beginning of May in Southern Ontario. At the first sign of potato emergence the rye is mowed off with a flail mower leaving a thick mulch of rye biomass. Specialized no-till planters for potatoes are not available so we used a RJ Equipment no-till plug transplanter. The planter must be able to deal with the biomass, penetrate undisturbed soil, space the seed, get the trench closed and create a minimum of bare soil.

There was no disturbance of the soil for weed control or hilling until digging in the no-till plots. In 2023 there were side-by-side plots of tilled and no-till organic potatoes randomized and replicated 4x's with 3 varieties Norland, Gemstar, Russet and SP327.

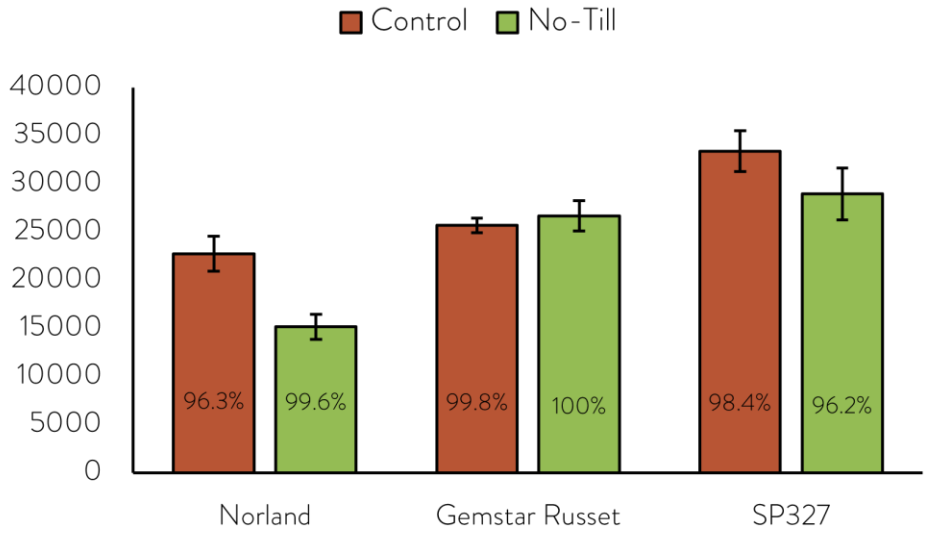

Fig. 1 Total yield in lb/ac of the 3 varieties in the no-till plots and tilled controls. The number in the bar is the % marketable after removing green tubers.

Compared to the tilled plots the no-till plots were about 3 weeks slower to emerge probably because of the cooler soil temperature under the thick mulch of rye. This delay on maturity was reflected throughout the rest of the season but did not affect the yields.

Fig. 2 One replicate of 4 showing 6 rows of the tilled control on the left and 6 rows of the no-till treatment on the right. The tilled plots required 2 row cultivations and 3 hand weedings to keep clear of weeds the no-till plots had no mechanical or hand weeding.

The variety Norland did have a significantly lower yield under no-till conditions but Gemstar, Russet and SP327 had statistically the same yield under both tilled and no-till.
Greening was not a significant problem with sufficient biomass to shield surface tubers from the sun. The rye gave very good weed control all season. Although the machinery used for planting and harvest were not typical of machinery on large scale potato farms it did demonstrate that there is machinery that can be made to do the job.

A whole farm approach to climate smart practices

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There are numerous climate smart practices that can be integrated into a farm and farmers should be at the forefront of adopting climate smart practices. However, there are many choices including efficient irrigation practices, solar electricity, solar hot water, energy efficient coolers, cover crops, crop rotations, biochar, and more. How do we decide which practice to invest in and when?

Based on the experiences of our carbon neutral farm, I will discuss the framework that we use to integrate these practices into our farm ecosystem, business planning, and marketing. What practices make good horticultural sense and what others might take more effort and work to apply? How do we evaluate cost vs. return? What practices should we be looking at for the future? Does being carbon neutral benefit our marketing? For example, some practices have been accelerated by government support through the Natural Resource Conservation Service. Other practices are based on reducing input costs. Other practices just make good business sense. And, some practices are just things we want to do. Everything doesn't happen overnight – join me for a discussion of how we set priorities, how we have achieved carbon neutrality, and what is on our yet to do list.

Diversified, Year-Round, Microgreens and Shoots

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Microgreens and shoots are the perfect crop for both beginning farmers and established farmers seeking year round production. With a quick (10 - 21 days) seed to harvest time table and low infrastructure needs, a farmer can quickly produce microgreens/shoots for market. What's more, micros and shoots bring in a high revenue per square foot and can be grown year round. They are a programmable crop with a simple spreadsheet for easy pass off to an employee.

I often advise beginning farmers to include microgreens in their crop plan. With a simple high tunnel or indoor propagation room with lights and a few hundred dollars to invest in trays, soil, and seed (many of which you may already have for your fledgling farm), you can be in business in just a few weeks after planting, providing you have a market. The propagation house, whether it is a heated greenhouse, a sunroom in the house, or a grow room in the basement, is crucial on a small farm, to be able to produce a succession of starts for our unique farms. In other words, beginning farmers will most likely already have the infrastructure set up for starting their own seeds. If you can find just a bit more space in your propagation house, microgreens could be your ticket to financial stability on the farm.

On my farm, the first thing we did when we landed in NY was to build our heated propagation greenhouse. It is 30' x 48'. We heat minimally to 45 degrees through the dead of winter and set up a 50% shade cloth June - August. We grow our microgreens, plus all of the starts for our organic farm, year round in this space.

We grow our microgreens in the paperpot trays, which are a big initial investment, but they will last a very long time, unlike the cheaper plastic trays which start breaking after a few uses. We use Vermont Compost potting soil - Ft. Vee mix - for all our microgreens, and we use organic pro mix for our pea and sunflower shoots. The higher quality, compost based potting soil you use will directly impact your yields. The peas and sunnies already have a nutrient reserve in their big fatty seed, so we can get away with using the cheaper pro-mix for these shoots. We use a rigid plastic 1020 tray with slits for growing our shoots.

For microgreens planting: Fill your trays evenly with compost based potting soil (we use Ft. Vee from Vermont Compost) and stack them ten high as you are filling so they get evenly pressed. Make sure the potting soil is not bone dry - if it is, water first. Measure out your seeds (see attached planting chart) and scatter the measured amount evenly right on top of the potting soil in your tray. Carefully water in - give a deep soak without spraying the seeds off the tray. Then restack the trays about 6 high and put an empty tray on top weighted with a cement paver. DO NOT COVER THE SEEDS WITH SOIL!

For shoot planting: Soak your seeds overnight. Fill your trays with pro-mix and deeply water the tray before planting (pro-mix is notoriously hydrophobic, so water water water). Scatter the soaked seed right on top of the soil, DO NOT COVER WITH MORE POTTING SOIL, then heavily water again. Stack 4 trays high with an empty, weighted tray on top. We use rectangular cement pavers as weights.

The microgreens will take anywhere from 3 to 10 days to germinate, depending on the variety. You will see them pushing the weighted trays right up, and even push them off if you don't get to them in time. It is very important to unstack your trays on time, otherwise the roots from the tray above will start to grow into the tray below, and you will have a very hard time pulling them off. There's more chance of mold wiping out your trays if you don't get them unstacked in time.

You don't want to uncover too early either, such as before the root hairs have fully buried themselves. The reason we stack and weight the microgreens is because we don't cover them with soil like we do with veggie starts. Since the microgreen seed is not covered, they require the weighted trays to encourage the root sprouts to bury themselves into the soil. One common mistake made by my employees is to unstack the trays too early. When unstacked too early, the freshly sprouted root hairs often perish when the hot sun hits them since they aren't yet buried in the moist soil. You will also learn to distinguish between fuzzy root hairs and mold….they look very similar!

In the coldest months, we turn one of our small walk in coolers into an incubation room. We set the heater to 68 degrees and put our freshly planted stacked trays into incubation for a few days. You must check the trays daily in here, for they will germinate much more quickly than in a 45 degree propagation house. This gives about a five day jump on seed to harvest dates in the coldest months.

To prevent attacks from rodents, we grow our shoots under cages that we built to fit 8 trays under, on a solid plywood table the mice can't squeeze through. In the coldest months the mice/rodents get real hungry and will start eating almost anything, including micro broccoli and cabbage. Since we don't use poison for rodents, and trapping is like a full time job, we choose to prevent attacks from rodents with cages. We are experimenting with tall metal tables - fingers crossed the mice/rats won't find a way to climb the metal table legs.

As far as marketing goes, microgreens and shoots are just asking for creative blends to be made. After experimenting with so many different blends, we have settled on 3 custom mixes that nearly sell out every week at our farmers market stands. One mix, we named "The Purps" and it is a blend of our favorite purple microgreens. It's gorgeous with a delicious, mild, and nutrient dense profile. We have done a lot of educating with our customers around the nutrient density of microgreens. Plus, we always carry a clean and high quality product that customers can rely upon week after week after week. We stick a label on our microgreen bags with our farm name and the product name so our customers can recall our farm name.

For packaging, we use a biodegradable bag from Clearbags.com. We use the Eco-Gusseted CSG-4 for our 1.5 oz bags and we use the CSG-5 for our 3 oz bags. We charge $5 for the 1.5 oz bags and $10 for the 3 oz bags. Therefore, we are getting $53 per pound for our microgreens at

market. For pea and sunflower shoots, we sell a 3 oz bag for $5, therefore our price per pound for shoots is $26 per pound.

Though production and sales change somewhat throughout the season, we average about $1300 in sales of microgreens every weekend at our farmers market stands. $1300 per week from 105 square feet in our propagation house! Times 50 weeks per year equals microgreens/shoots bringing in $65,000 annually on our small farm. This is an incredibly valuable product that brings in a reliable weekly sale from a tiny amount of space. We have trained an employee to do the tray filling and planting, and I do the tray management, watering, and harvesting. We spend around 8 hours per week planting, managing, harvesting, washing, and packaging the microgreens for market.

Over time we have culled our varieties down to the highest yielding, tastiest, and easiest to grow microgreens and shoots. We currently grow pea and sunflower shoots, and for microgreens we grow arugula, broccoli, red cabbage, daikon radish, red rambo radish, purple kohlrabi, red Russian kale, mizuna, Tokyo Bekana, cilantro, red amaranth, and basil.

As far as leftovers go, microgreens are an incredible supplement to a pastured chicken operation. Layer hens will have the darkest orange yolks when eating microgreens, and your egg customers will go gaga for your eggs, then you can sell the eggs at a premium price…we sell ours for $10/dozen. You can also experiment with air drying microgreens, then blending in a certified kitchen to sell as Super Greens powder for customers to mix into smoothies or otherwise use as a health supplement.

Lovin' Mama Farm Microgreen Seeding Rates

Micro green seeding rate per tray (paper pot tray size is 12” x 24")

Amaranath	1 Tbs
Arugula	1 Tbs
Basil	1 Tbs
Broccoli	2 Tbs
Cilantro	3 Tbs
Daikon radish	3 Tbs
Mizuna	1.5 Tbs
Purple kohlrabi	1.5 Tbs
Rambo radish	3 Tbs
Red cabbage	2 Tbs
Red Russian kale	2 Tbs
Tokyo bekana	1.5 Tbs

Shoot seeding rate per tray (1020 tray size is 10" x 20")

Peas (soaked)	3 cups
Sunflower (soaked)	2 cups

Lettuce for Hot Weather: Effects of Variety, Mulch, and Shade

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In the Mid-Atlantic region, lettuce production is typically constrained to the spring and fall since high temperatures can induce premature flowering (bolting) and development of bitter flavor in lettuce. Over several seasons, I have tested three strategies for maintaining quality lettuce during summer production: use of heat tolerant varieties, use of shade cloth and use of white and silver plastic mulch. I have also tested using these strategies in combination. All the trials were conducted at University of Delaware's research farm in Georgetown, Delaware.

Heat Tolerant Varieties

In all the trials I have done, variety has been the most significant factor determining premature bolting and development of bitter flavor. Some varieties are slow to bolt but still develop bitter flavor. In 2023 I tested 14 lettuce varieties that were reported to be heat tolerant for performance with early and late June planting dates. In 2024 I trialed the six most heat tolerant varieties from the 2023 trial along with 22 varieties not previously tested. The 2023 trials were transplanted into white plastic mulch and shaded with 30% black shade cloth. The 2024 trials were transplanted onto white and silver mulch with no shade.

Bitterness was rated on a 1-4 scale with ratings of 1 and 2 considered marketable and ratings of 3 and 4 considered unmarketable. Bolted heads were also considered unmarketable. In 2023 the varieties with the lowest bitterness and bolting in the early June planted trial were Skyphos, Muir, Nevada, Jericho, Salanova Red Tango, and Sunland (Table 1). In the June 22, 2023 planted trial, harvested in early August, only Muir and Nevada produced marketable lettuce.

Table 1. Flavor Ratings for Lettuce Varieties Transplanted on June 5, 2023 and Harvested in Early July

Variety Name	% Bolting	Flavor Rating*	
Skyphos	0	1.0	a**
Muir	0	1.1	ab
Nevada	0	1.1	abc
Jericho	0	1.2	abc
Salnova Red Tango	8	1.3	abc
Sunland	0	1.4	abc
Salanova Red Butter	50	1.4	bcd
Verigo	50	1.5	cde
Rubygo	0	1.8	def
Salanova Green Oakleaf	50	1.8	efg
Adriana	50	1.9	fg
Starfighter	25	2.0	fg
Salanova Green Butter	50	2.1	g
Red Cross	46	3.2	h

*Flavor was rated on a 1-4 scale with ratings 1 and 2 having marketable flavor and 3 and 4 being un-marketable.
**Averages followed by the same letter are not statistically different from one another.

In 2024, the varieties with the lowest bitterness and bolting in the early June planted trial were Baja, Kalura, Nevada, Muir, Skyphos, Mikola, Hanson Red, Victoria Batavian, Salanova Red Tango and Sunland (Table 2).

Table 2. Flavor Ratings for Lettuce Varieties Transplanted on June 6, 2024 and Harvested in Early July

	Silver Mulch		White Mulch	
Variety Name	**% Bolted**	**Flavor Rating***	**% Bolted**	**Flavor Rating**
Baja	17	1.0	6	1.0
Kalura	0	1.1	0	1.1
Nevada	6	1.1	0	1.1
Smile	50	1.0	44	1.2
Muir	0	1.1	0	1.2
Sparx	39	1.1	33	1.3
Skyphos	0	1.1	0	1.3
Panisse	39	1.3	33	1.2
Mikola	0	1.0	0	1.5
Slogun	22	1.5	22	1.1
Hanson Red	0	1.3	0	1.3
Victoria Batavian	11	1.5	6	1.2
Salnova Red Tango	0	1.6	0	1.2
Sunland	6	1.4	0	1.4
Magenta	6	2.0	11	1.0
Chalupa	0	1.5	0	1.6
Bambi	50	1.9	56	1.2
Galisse	11	1.7	22	1.5
Romulus	22	1.6	6	1.6
Ear of the Devil	50	1.6	50	1.8
Vulcan	50	1.2	50	2.3
Sangria	50	1.6	50	2.3
Winter Density	17	2.3	6	1.8
Saragossa	0	2.6	0	1.9
Jericho	50	2.1	44	2.5
Green Star	50	2.7	44	2.5
Tropicana	50	2.2	50	3.1
Bunyards Matchless	100	NA	100	NA

*Flavor was rated on a 1-4 scale with ratings 1 and 2 having marketable flavor and 3 and 4 being un-marketable.

Light Colored Mulch

In 2023 I tested the effect of silver and white plastic mulch on lettuce yield and quality. A bare ground treatment and a black plastic mulch treatment were included as controls. Silver mulch produced the largest lettuce plants and the least bitter lettuce. White mulch also improved lettuce flavor, but not as much as silver. In 2024, I compared 28 varieties on white and silver mulch. In the early June planted trial, there was not a significant difference in bolting or bitterness between

the white and silver mulch. The data from the 2024 late June planting is still being analyzed. In both years' trials, silver or white mulch did not overcome the effect of variety. Heat sensitive varieties still bolted and became bitter on silver and white mulch. You cannot produce marketable lettuce under hot conditions if you are not also using a heat tolerant variety.

Shade Cloth

In trials planted in 2018 and 2019, use of 30% black shade cloth reduced bitterness in lettuce, however these trials were planted in early April and harvested in early June. In the 2023 trials, which were planted in June and harvested in July and August, 30% black shade cloth decreased lettuce plant size and had no effect on bitterness. In all these trials, shade cloth was applied over low tunnels, which may have a heat trapping effect. Shade cloth might be more effectively used to reduce air temperatures for lettuce crops grown in high tunnels.

Conclusions

If you want to try producing lettuce for harvest in July and August, using an extremely heat tolerant variety is vital. Using white or silver plastic mulch can also help reduce bolting and bitterness in summer lettuce. It is unclear whether there is a consistent benefit of using silver mulch over white mulch. Shade cloth (30% black) on low tunnels did not increase marketable yield in summer lettuce and is probably not worth the cost and trouble in this production system.

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Summer Greens Production at la Ferme des Quatre-Temps

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Catherine is an agronomist and leader of the market garden team at la Ferme des Quatre-Temps. The farm specializes in greens production and, aside from greenhouse tomatoes, they are their best seller. The Market Gardener team prides itself in having the most absolutely delicious mesclun mix at the farmer's market.

Catherine will discuss the nuts and bolts of their salad mix, lettuce, radicchio and kale production throughout the main growing season, including variety selection, succession planting, cultivation, and efficient harvesting and conditioning for improved profitability. Catherine will also provide details on pest and disease management in their leafy greens.

Variety selection

Green varieties should vary with the season : cold hardy varieties for shoulder season and heat loving varieties for the summer.

I'll present my favorite ones and we'll discuss some case studies of more tricky ones like radicchio where day length is a deciding factor.

Succession planting

Summer greens are a very profitable crop on a small-scale farm, because they grow really fast and have a quick turnover. The challenge is to have a continuous harvest throughout the year.

Fortunately, they are some easy tricks to ensure this reliability :

- Careful crop planning
- DTM varying with the season
- Using tunnels for season extension

Weed management

Ferme Quatre-Temps is a farm school where the whole production is managed by students with little experience. The result is : mistakes are made with weed control and weeds have gone to seed in the last decade.

With high weed pressure, direct seeded greens have to be managed consciously. We have developed a full proof procedure, because we had no other choice :

Step 1 : Stale seed bed
Step 2: Flame weeding
Step 3 : Two bad cats tine weeder (2 times/week)
Step 4 : Wire weeder (once, only if needed)

Efficient harvesting and conditioning

- Most of the work on greens is done when harvesting and conditioning them. Simplicity is the keyword with these steps.
- The goal is to reduce the work that needs to be done to increase profitability.
- An easy way to improve these steps is to give employees time targets and provide step by step movements.

Problems and how to solve them

Greens can be highly profitable or a huge headache. There are a few things you need to prevent before they become big problems.

- Pests : the worst one we have is flea beetles. Can mostly be controlled with systematic insect nets.
- Diseases : the worst ones are cercospora leaf spot in swiss chard and fungal diseases in radicchio.
- Spotty germination: controlled irrigation during germination is key.

La Ferme des Quatre-Temps will be 10 years old in 2025. What I've seen over the last few years, is that problems can become more complex on aging farms. I'll discuss some that we have and how we are trying to manage them. One is overgrown hedge rows. Another one is high salinity in over-fertilized soil.

Striving Toward Improved Efficiency and Profitability Through Equipment Investments and Wash-Pack Improvements for Leafy Greens at North Point Community Farm

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We are a diversified vegetable farm growing about 25 acres in annual production in Plattsburgh, NY, 2022 was our first season. We distribute vegetables approximately 30 weeks of the year through our 200 member CSA, two farmers markets, and local and regional wholesale accounts. All of these outlets require a wide variety of crops to be successful, but wholesaling cut greens quickly became the outlying anchor in this picture, accounting for 20% of gross revenue our first season. Since then, we have followed market demand and made strategic investments in equipment and machinery to increase cut greens profitability. This has not only led to greater success in cut greens production, but has also bolstered the farm by giving us the financial capacity to improve production of other crops and systems.

We did not anticipate growing such a large volume of greens our first season, and started low tech with three rows on a six foot bed and hand harvesting. In retrospect this seems like a waste of space and a laborious task, but with our small team and large acreage it was important to us to be able to mechanically cultivate, which was limited to a three row system. However, as the weeks, months, and years went on we have scaled from three rows on a bed, to six rows, to nine rows, to twenty. Each of these evolutions in row density corresponded to cascading changes in every aspect of greens production. These changes felt like a slow process at the time, but after being unable to fill orders, spending a huge amount of time both seeding and harvesting cut greens, and double, triple or even quadruple cutting beds and seeing quality plummet, it was clear that dramatic changes needed to be made.

These system changes have come with a close eye on weekly revenue and labor from cut greens, and have been implemented in phases over the last three years, with many more to come. We have made improvements in four distinct areas: bed preparation, seeding, harvesting, and wash/pack.

We have had many different iterations of bed prep for seeding greens including a rock picker, tine weeder, basket weeder, offset disk, perfecta harrow, cultipacker, and rototiller. Creating a flat, even, and weed free bed top is the key to a successful greens planting and we are still figuring out how to best achieve this. Most recently we have had the greatest success using a bed width rototiller as the final step after primary tillage and stale bedding. We farm beautiful loamy soil, but it has a lot of rocks, and our current bed prep tools are not able to effectively address this. We are considering purchasing a stone burier or more aggressively rock picking prior to planting.

We sow direct seeded leafy greens weekly around our schedule and forecasted rain. If there is no rain predicted for a given week, seeding is done late in the day and we make sure irrigation is

ready to be turned on. We have found low tech MegaNet wobblers to be the most efficient and effective for watering in direct seeded greens.

One of our first purchases as a farm was a three row jang seeder on a toolbar because it could seed everything. The inefficiency of a three row cut greens bed quickly became clear and our first green's specific equipment purchase was a tine weeder. This facilitated a means of cultivating more than three rows. We got creative and began moving the jang seeders around on the toolbar, at first doing two passes per bed to seed six rows, and eventually three passes per bed to seed nine rows. This was certainly an improvement, but an extremely arduous and time intensive weekly task, and it was clear that we would benefit from even denser seedings. Our gross revenue grew by 40% from our first to second season, and in that growth wholesale cut greens still accounted for almost 20% of sales. We decided that this justified substantial investment and bought a 20 row dedicated greens seeder made by Sutton Ag. It took about a month of failed seedings to learn fertility, speed, plate selection, and seed depth. As we increased rows we increased fertility, but we found it to be particularly challenging to manage. Losing crops to lack of nutrients was a big eye opener to the complexity of scaling any system. It took time to figure out and dial, but now greens seeding time is reduced by at least half, weeds are much better managed, harvest is smoother, and our product is higher quality.

We mechanically harvest with both a Sutton Ag push HarveStar and Farmer's friend quick cut greens harvesters. We choose between these two tools depending on crop, height, quality, and quantity harvested. These tools save us hours of labor weekly, which evidently has made our greens program much more profitable since the 3 row hand cutting days. If a planting is perfect two people can harvest 100 pounds of greens in ten minutes with the HarveStar. We harvest into clean flip top bins that are stored in our harvest box truck. The truck keeps both empty and full bins shaded and cool before a crop drop is made to our wash house. As bins are unloaded they are labeled with colored stickers to indicate which crop is in what bin. To wash we use a two dunk stainless steel tank system with jacuzzi bubblers for agitation. We drip dry our greens in fishing baskets before they are spun dry in our two converted washing machine greens dryers. The finished dry product is stored in our pre-pack cooler labeled to be packed by our greens bagging crew later in the day.

We manufactured greens packing tables that are on wheels, have stainless steel table tops, and built in fans and lights. These tables are easily cleaned, the fans help excess moisture evaporate, and the lights help to spot any rotten leaves or weeds that have been missed during harvest and wash. We sell most of our greens in half pound resealable retail bags. Typically four people work at the greens pack table, sharing two scales, and are able to bag 100 bags in under 45 minutes. The bagged product is then repacked into clean flip top bins labeled with location, product name, date, and a count of how many bins of each crop are going to each place. After each cut green crop is packed the pallets of labeled bins get wheeled into our shipping container cooler.

Once harvest, wash, and pack are complete, all finished product gets loaded into our delivery vehicle for delivery the next day. We retrofitted a dry box truck into a farm hacked reefer truck. We insulated the box with fiberglass insulation and foam board and cut a hole in the box directly above the cab for a 24,000 BTU AC and Cool Bot. We made a custom extension cord and installed a 240 V outlet next to our loading dock. The truck is loaded and plugged in at the end of

the day so in the morning our delivery driver unplugs the truck and drives away with everything at 38 degrees. The majority of our cut greens sold are offloaded at the first stop on our delivery route, so even though we are four hours from the farm the integrity of our product is minimally diminished. Nonetheless, we are researching installing a more powerful alternator in the truck to allow the system to run while the truck is on the road.

Looking to the future we are striving towards seeding more precisely and managing fluctuating demand, finding better strategies for creating a flat and even bed top, reducing the time spent bagging greens, becoming GAPs certified for increased market access, and figuring out how to get greens cooler faster and for longer to ensure we're delivering a high quality product.

Embracing Bitter Beauty: Radicchio Varieties and Their Performance in the Northeast

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Radicchio (*Cichorium intybus* var. *latifolium)* is grown widely throughout Europe, especially northern Italy. Within radicchio, there are several groups that differ in color and shape. These bitter and colorful greens are commonly used as components of salad mixes or as the sole component of winter salads, and some types are more commonly braised or grilled. In addition to having interesting color and flavor profiles, they are rich in phenolics and other bioactive compounds. The availability of varieties to commercial growers in the U.S. has expanded greatly, but there remains a need for reliable regionally relevant information about performance of the varieties and types available.

What We Did. In Durham NH, we grew 30 (2022) and 34 (2023) cultivars of radicchio belonging to seven main groups (Chioggia, Castelfranco, Treviso, Sugarloaf, Verona, Rosa del Veneto, and Lusia). In both years, we seeded on 20-21 June, and transplanted on 14-15 July. Plants were harvested and weighed as they reached market maturity. We noted plants that were not marketable due to bolting, rot, tipburn, or failure to head. We used standard cultural practices: plants were grown in double rows on 30-inch-wide raised beds covered with white-on-black plastic mulch with drip irrigation. Fertility was applied pre-plant: 110 lbs/acre of N and 150 lbs/acre of K_2O. Plants were spaced 12 inches apart in each row, and each plot had 16 plants. We used a randomized complete block design with 4 replicates of each cultivar.

In two locations (Durham NH and Monmouth ME), we evaluated the effects of planting date on harvest window, bolting, and crop marketability. Using three round red Chioggia cultivars ('Sirio', 'Leonardo', and 'Perseo'), we seeded at four dates: early May, late May, late June, and mid-July. Plants were monitored twice a week until frost, and we noted when each head reached market maturity, when it stopped being marketable, and the reason for unmarketability.

Performance of Varieties & Types. In both years (2022 and 2023), we observed tremendous differences between varieties. For example, the percentage of heads that became marketable ranged from 0-94% in 2022, and from 10-95% in 2023. Several varieties had very high percentages of unmarketable heads, due to tipburn, rot, bolting, or failure to head (likely due to insufficient days to maturity). For the purposes of this report, we are presenting results by type, because the different types of radicchio would be marketed for different uses, and we think that the most useful information is about relative performance between types and between varieties within a given type. See Figure 1 for detailed performance data.

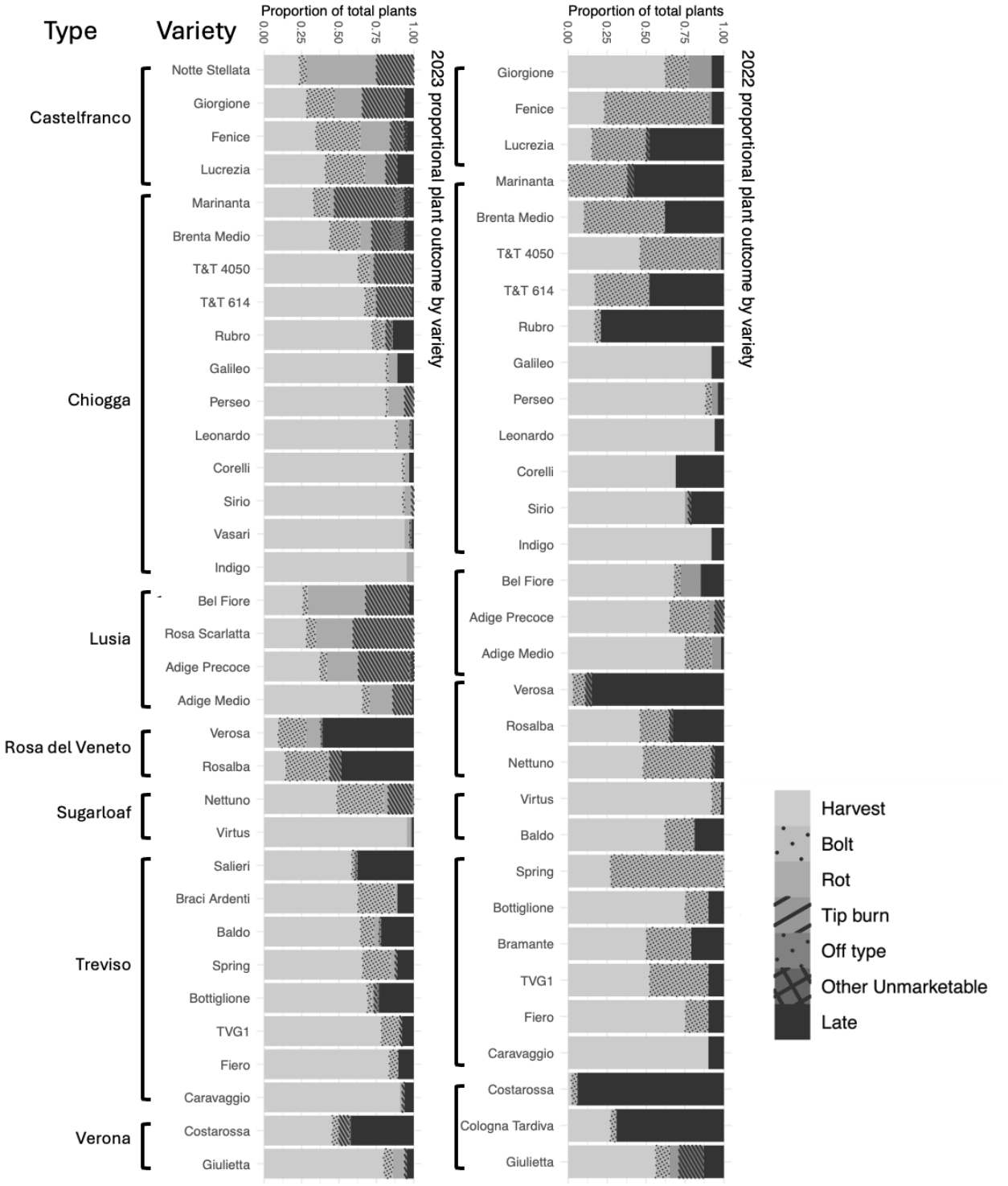

Figure 1. Performance of several radicchio varieties in 2022 and 2023 at Woodman Farm in Durham NH. Each bar shows the percentage of plants that were harvested, bolted, rotted, had tipburn, were off-type, unmarketable for some other reason, or failed to reach maturity (late).

Slotting/Planting Date vs. Harvest Maturity. For the three red Chioggia varieties seeded in early May, late May, mid-June, and mid-July, harvest window (the number of days that a given head was marketable) varied between cultivar and seeding date. All three varieties had a high percentage of marketable heads – ultimately exceeding 93%, except for the last planting. While ultimately several heads did bolt, all cultivars did have a reasonably long maturity window. The longest harvest window was observed with planting C (planting in 3rd week of June) in 2022, and planting D (planting in mid-July) in 2023. Results for NH are shown below; but results were similar in ME and NH.

Maturity Window (days marketable) for radicchio seeded at different dates, 2022 and 2023

	2022 Seeding Date			
Cultivar	**A (5/5)**	**B (5/26)**	**C (6/22)**	**D (7/15)**
Leonardo F1	23.7	34.9	43.9	25.2
Perseo	18.7	20.8	29.7	30.8
Sirio	19.7	23.8	39.7	28.3
2022 Overall	*20.7*	*26.5*	*37.8*	*28.3*
	2023 Seeding Date			
	A (5/10)	**B (5/30)**	**C (6/21)**	**D (7/10)**
Leonardo F1	25.3	29.5	35.6	38.7
Perseo	14.5	21.9	26.4	27.7
Sirio	16.7	23.7	25.1	28.1
2023 Overall	*18.8*	*25.0*	*29.0*	*31.4*

Conclusions

- Variety selection is critical for success in producing radicchio, as varieties differ greatly in the percentage of marketable heads produced and susceptibility to production issues such as bolting, bottom rot, and tipburn.

- For traditional round red Chioggia types, several varieties had very high percentages of marketable heads, and appear to be well adapted to production in the northeast.

- Other market classes offer attractive colors and different culinary uses. We identified varieties within both sugarloaf and Treviso types that were well adapted, with high percentages of marketable heads.

- The varieties we evaluated within the Lusia and Rosa del Veneto types were especially interesting from a culinary and attractiveness point of view, but were the most difficult to produce, with high percentages of rot (Lusia types) and very long days to maturity required (Rosa del Veneto types).

- Seeding in the third week of June maximized the harvested window for the three Chioggia varieties we looked at (Perseo, Sirio, and Leonardo), and appeared to work well for many of the varieties in the variety trial. Earlier or later dates might work better for some varieties that failed to mature or to lengthen the harvest window for early-to-mature

varieties. (In 2024, we attempted planting the Rosa del Veneto cultivars much earlier to see if they would mature earlier; they still largely failed to mature prior to frost).

- For Chioggia types, harvesting every two weeks would prevent losses due to bolting for the three varieties we used in slotting experiments (Perseo, Sirio, and Leonardo). Conservatively, we would suggest a weekly harvest to minimize crop losses.

We repeated this study in 2024 and we will update this report as more results become available. With any questions, please contact the author at: becky.sideman@unh.edu or 603-862-3203. You can follow the Sideman Lab's work on Instagram @unh_sidemanlab.

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Promising Developments in Elderberry Production

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Thanks for inviting me to present at the 2024 New England Fruit and Vegetable Conference on exciting developments with American elderberry. I last participated in the NEFVC in 2011, sharing thoughts on elderberry production and our midwestern experience with this underutilized native fruit. Much has happened in the world of elderberries since, and I'm as excited now as I was then with the potential for this crop.

First of all, let's take a look at the past and present situation of elderberry production in the US. Elderberry work at the University of Missouri began in 1997, and soon after this modest start (a cultivar trial), we surveyed berry researchers and extension colleagues across the nation, to get a feel for the state of the industry. While elderberry has a long history of utilization among Indigenous peoples and immigrants, most of the elderberry crop from these early times to the late 20th century was wild harvested. We identified modest commercial production in several areas, lots of backyard plantings, and an industry that was focused on berry use in jelly, juice, and wine. We also identified interest in this crop among the berry farming community, the research/extension community, and the public at large. Moving ahead to 2017, the US Census of Agriculture that year identified 790 acres of elderberry production on 1226 farms (mostly small farms) across the nation. The most recent Census of Agriculture (2022) revealed 2629 farms producing fruit on 1682 acres, a doubling of the industry in 5 years. Missouri is an important elderberry producer, with many of the larger farms (7% of the total farms) producing crop on 36% of the total acreage in 2022. A number of states host elderberry research and extension activities, farmers from many states and countries attend the annual Missouri Comprehensive Elderberry Conference, and granting agencies (including the USDA) have generously supported elderberry work. Other interesting developments include a focus on plants parts in addition to berries (blossoms, leaves) and a diversification into a multitude of value added products (health supplements, cosmetics, freeze dried products, food colorants, flower products) that include elderberry as an ingredient. Research interests have moved beyond basic horticulture into metabolomics and an understanding of the genetic potential of this crop. These amazing developments are due in large part to a productive coalition of innovative farmers and berry processors, researchers, and extension/outreach educators.

Missouri's research and extension work with elderberry is the result of collaboration among University of Missouri, Missouri State University, and Lincoln University. Early work focused on profitable and sustainable production practices, cultivar development, development of production budgets, and understanding the current and potential market for elderberry and elderberry products. The sum of this early work was published in *Growing and Marketing Elderberry in Missouri* in 2014, a publication that was subsequently revised twice and is scheduled for another revision. The developments that I will present today are the result of recent work.

Elderberry cultivars developed since 2000 are largely superior wild selections. The initial University of Missouri/Missouri State University releases of 'Bob Gordon', 'Wyldewood', and 'Ranch' were recently joined by the cultivar 'Pocahontas'. 'Pocahontas' is productive, develops large umbels on annually renewed plants, and has desirable juice qualities for value added products. 'Pocahontas' responds favorably to annual renewal pruning. The original plant was found near Pocahontas, AR. 'Pocahontas' does have a tendency to lodge canes at windy sites. Now let's turn the spotlight on the University of Missouri elderberry breeding program, which is hosted at the University of Missouri Center for Agroforestry. This recently established program has the goals of developing superior elderberry cultivars through an in-depth characterization of American elderberry (including the development of a reference genome). The elderberry breeder, Dr. Elizabeth Prenger, has evaluated several thousand seedlings that are the result of both targeted pollinations and open pollenated seed collections. A number of first round selections are under further evaluation. Initial work on characterizing the American elderberry genome points out that this plant has a large and complex genome of approximately 14 billion base pairs (compare to the human genome, which has 3 billion base pairs). Other work in targeted breeding of American elderberry is underway at the Savannah Institute. Additional work on understanding the variability of American elderberry is underway with a large GxE study that includes a select group of cultivars at 5 sites across the Midwest. This project has identified cultivars with mite resistance and cultivars with wide environmental adaptation ('Ranch', 'Pocahontas', 'Hamilton' and 'East Grove') that might be useful as parents in controlled breeding.

American elderberry responds favorably to fertility management. Recent developments in understanding nitrogen fertility management point out that while American elderberry productivity and plant height are positively influenced by increasing nitrogen rates (the study looked at 0, 50, 100 and 150 lbs actual N per treated acre), other measures including pest susceptibility and juice quality were not influenced by nitrogen rate. Foliar nitrogen content was positively influenced by nitrogen fertilization rate, as might be expected. This observation led in part to an emphasis on developing standard compositional values for nutrients in elderberry foliar samples. These values are necessary for an understanding of "normal' elderberry foliar sample nutrient content, and for the development of foliar sampling as a tool for monitoring nutrient application programs and diagnosing suspected nutritional disorders. A huge thanks is due to Sydney Moore, who collected and analyzed thousands of foliar samples with the goal of developing standard compositional values. We now have standard compositional values for N, P, K, Ca, Mg, Fe, Cu, Zn, and Mn from foliar samples collected in May, which will soon be published. More work is still to be done, looking at different collection points during the elderberry life cycle.

Elderberry is commonly propagated via hardwood cuttings. A recent two-year study led by Caleb O'Neal at the University of Missouri demonstrated that good rooting and subsequent plant survival can result from 2 node cuttings of medium to large size. The study pointed out that cuttings that are stuck in the field early (late February) may produce better plants than cuttings stuck later in the spring (April-May). Basic horticulture, but this study answered several questions about effective cutting propagation.

In past years there was disagreement in the literature regarding pollination requirements for American elderberry. Recent work by Dr. Michele Warmund's team at the University of

Missouri demonstrated that American elderberry is functionally self-infertile, and that most pollination is accomplished by wind (though a number of insects were observed visiting elderberry umbels). Elegant research looking at stained pollen tube growth pointed out the need for cross pollination. The work also demonstrated that self-pollination, while occasionally successful, led to poor berry set. This work points out the importance of providing for cross pollination by planting different cultivars with overlapping bloom periods in elderberry fields. The work also suggests that elderberry might respond favorably to controlled pollination via drones or sprayers. Pollen collection is relatively easy from elderberry florets, and the pollen stores well.

While many elderberry plantings are still in the "grace period" before production-limiting pest problems become an issue, farmers' experience in Missouri and elsewhere point out that American elderberry is not free from insect pests. While we have a good understanding of traditional pests (Japanese beetle, elderberry longhorn beetle, elderberry spindle worm, elderberry sawfly), several insect and mite issues are under additional study. Dr. Warmund's team has characterized the eriophyid mite situation, including an understanding of life cycles that has led to potential control strategies. This work also identified a newly described mite. Dr. Warmund characterized Jessie's bug as a potential elderberry pest of shoot tips and developing umbels, and two insects whose larval stages can cause elderberry flower bud galls. Additional work at Lincoln University and Missouri State University is focused on spotted wing drosophila management using several types of lures and trap combinations. Stay tuned for more developments! Dr. Warmund focused on disease issues as well, characterizing elderberry orange rust and elderberry phoma disease. Much of this work was included in *Elderberry Insect and Disease Management*, the first published spray schedule for field grown elderberry.

The virus situation in American elderberry is poorly understood. Virus infection is assumed to be a comprehensive situation, since most cultivars are wild selections, limited efforts are in place to "clean up" elderberry cultivars, and because of the lack of elderberry propagation protocols. The impact of plant virus infection on elderberry plant health is unknown. Recent work at the University of Missouri Plant Diagnostic Clinic included 2 years of sample collection of both wild and cultivated American elderberry across Missouri. As expected, no varieties were tested completely virus free in Missouri. Elderberry carlavirus C and elderberry carlavirus D are the two most prevalent viruses for Missouri elderberries. The two viruses don't cause visible symptoms in most of common cultivars. Interestingly, a number of the samples were infected with multiple viruses. The next step with the virus situation is to develop "clean plants" of important cultivars, which can then be the basis for propagation material that is virus tested. We have provided plants of 4 American elderberry cultivars ('Ranch', 'Bob Gordon', 'Wyldewood', and 'Pocahontas') to the University of Arkansas Clean Plant Center for additional virus testing and for the process of virus elimination.

Several elderberry production budgets are available nationally. A particularly useful budget is found at the University of Missouri FAPRI site; this budget is currently under revision, with an updated version available soon. Several projects focused on understanding the marketing and economics of elderberry are underway at University of Missouri. A recently published national survey focused on knowledge of elderberry, preferences for elderberry products, and a discrete choice experiment that asked about price, farming practices (organic, pesticide-free,

conventional), origin of elderberries (American-grown vs. European-grown), and carbon-neutral claim. Interesting highlights from this study, which included 1036 participants, included: 75.3% were familiar with elderberry, 41.2% had consumed elderberry products, 38.3% consumed elderberry more than 10x per year, 99.7% were more likely to purchase American-grown elderberry products, and 94.1% were more likely to purchase elderberry products with carbon claims.

Finally, outreach activities on the part of land-grant extension systems, non-profit organizations, and others have developed phenomenally in recent years. Online resources have proliferated, and growers' organizations are in place to provide farmers with peer support and guidance. As a final comment, stay tuned for interesting developments on the relationship between elderberry and human health. Labs at the University of Missouri and elsewhere are investigating the role of elderberry in supporting brain health, combating infection, and aiding healing after injury. These finding will be published in scientific journals, as well as discussed on websites such as the Advancing American Elderberry site. The future is exciting for American elderberry!

Resources

Advancing American Elderberry https://elderberry.missouri.edu/

American Elderberry Production Budget https://fapri.missouri.edu/wp-content/uploads/2023/05/MO_Elderberry_CoP.xlsx

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How to Establish a Successful Hazelnut Orchard in New Jersey

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Hazelnuts have been profitable in the Pacific Northwest region of the United States for nearly a century, and significant research shows their potential to be a profitable temperate tree nut crop for growers on the Northeastern Coast of the United States. Prior to establishing a hazelnut orchard, it is critical for growers to have an understanding on how to prepare, maintain and harvest one. This presentation will serve as a primer for hazelnut orchard establishment considerations for Northeastern growers and will address the following main aspects of hazelnut production.

Site Selection

Hazelnuts grow best in medium textured, well drained soil. Orchards should be surrounded by deer fencing and should be located as far from a tree line as possible to minimize the potential for rodent related crop loss.

Site Preparation/Planting

The soil pH of a hazelnut orchard should be at or around 6.5 to ensure optimal nutrient availability. Hazelnuts have moderate fertility requirements which should be incorporated prior to planting and include 150 lb/A K_2O. Nitrogen applications should begin at the 3rd leaf (0.25 lb N/tree) and then steadily increase till maturity 10th leaf (0.75 per tree lb N/tree).

Potassium, nitrogen and all other macro and micronutrients should be monitored with summer leaf tissue analysis through the life of the orchard.

Trees should be planted at 20 x 20 foot centers with 108 trees per acre, to allow for maximum yields and ease of equipment movement. Pollenizers should be interspersed every third tree in every third row.

Plant Material

Hazelnuts are monecious, wind pollinated and self-incompatible. Careful consideration must be made when choosing which hazelnut trees to plant to ensure they will pollinate each other and to ensure they have resistance to the deadly fungal disease eastern filbert blight.

There are hundreds of hazelnut varieties grown throughout the world. However, there are a limited number that are best suited to Northeastern US winters and disease pressure. These cultivars are detailed in the Rutgers University Factsheet ‘Choosing Plants for a Hazelnut Orchard in New Jersey’. https://njaes.rutgers.edu/e368/

Pest and Disease Management

Eastern Filbert Blight is the most devastating fungal pest to hazelnuts in the Northeast. It is a cankering disease which infects the cambium of the trees, this eventually leads to girdled branches and limbs until the trees die. Disease resistant cultivars are the first line of defense.

Bacterial Blight is the second most devastating disease in hazelnuts. Symptoms can range from foliar necrosis to girdling of the trunk. The primary method of control is to spray copper based pesticides in early fall.

Filbertworm is one of the most significant insect pests in hazelnut orchards. It will feed on and destroy kernels. They emerge late June through early October, and pheromone traps can successfully detect their presence. Once threshold levels are reached, insecticides can be sprayed for control.

Brown Marmorated Stink Bug has emerged in recent years as a major pest in hazelnuts. It feeds on the nuts and can cause blank nuts and corking. Fortunately, there are a number of insecticides that have been shown to be effective against them.

Pruning and Maintenance

The natural growth habit of hazelnuts is a bush, but it is recommended that they be pruned to a single leader to aid in management and harvest. Throughout the life of a tree suckers need to be pruned back or sprayed with herbicides to maintain the upright growth habit.

Aroniaberry: A Native Superfood Pome Fruit

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Aroniaberry, *Aronia mitschurinii*, is a unique small fruit crop belonging to the *Rosaceae* family with long-standing nutraceutical interest. This pome fruit is a hybrid between Black Chokeberry, *Aronia melanocarpa*, and European Mountain Ash, *Sorbus aucuparia*. Hybridization has led to several production improvements such as a compact crown, non-rhizomatous growth, and larger fruit with a higher water content than its native, black-fruited parent, *Aronia melanocarpa*. Despite varying tradenames (Viking, Nero, etc.), there is a single genotype in production. Aroniaberry is of interest primarily due to its incredibly high levels of anthocyanins and other phenolic compounds which provide a host of human health benefits. Due to its dry, astringent flavor, Aroniaberry is generally not grown for fresh consumption, but rather for processing. Recent studies have sought to develop standard production practices for this unique fruit crop.

Aronia has an expansive native range which affords it adaptability to a variety of environmental conditions. Aroniaberry prefers a pH of 6.0-6.5 but will tolerate pH conditions from 5.0-8.5. Plants should be spaced 3-4' within and 12-14' between rows. Fruiting occurs primarily on mature laterals with the first significant crop seen in the 3rd year after planting. It is recommended that approximately 90 lbs./acre of granular 15-6.5-12, or similar, fertilizer be applied as a single application in the spring for sufficient annual fruit production. Our fertilizer trails revealed that Aroniaberry prefers an NPK ratio of 3-1-2, branches more readily with increased phosphorus fertilization, and suffers from induced potassium deficiencies with higher levels of calcium and magnesium fertilization. Pruning is only required as a rejuvenation/renewal practice in aging orchards (8+ years) that have seen marked decreases in production or to maintain orderly plantings. There is no benefit from shoot thinning. Renewal pruned plants return to full production in the 3rd year following pruning and yield as much fruit as newly planted 3-year-old plants. Renewal pruning also serves to concentrate fruiting and increase the number of fruits per infructescence.

Aroniaberry is fairly tolerant of pests. Tent caterpillars, Japanese Beetles, Lace bugs, and Brown Marmorated Stink bugs have all been found to infest Aroniaberry, but never to any impactful level. For diseases, Powdery Mildew, Fireblight, and Cedar-Apple Rust will all infect Aroniaberry, however, none of these issues have been observed to be severe or pose a significant challenge to production. In dry conditions, especially during fruitlet development, Aroniaberry will drop its fruit. Therefore, it is recommended that Aroniaberry be irrigated regularly (1"/week), until harvest. Marketing can also be a challenge. It is recommended that growers slowly introduce Aroniaberry to their customer base. Aroniaberry will prove to be a more viable option for operations with existing processing facilities (winery, bakery, etc.) or with customers interested in healthy foods and processing.

Growing Artichokes in New England

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Globe artichoke (*Cynara cardunculus* var. *scolymus*) is a plant in the Asteraceae family that is native to the Mediterranean region. Italy and Spain lead artichoke production worldwide, and the vast majority of artichokes produced in the US come from Monterey County, California. However, artichokes are a high-value crop that can, with care, be produced in other regions of the US, including the Northeast. Here, locally grown artichokes can be sold as interesting and luxurious novelties at farm stands, farmers' markets, and local retailers and restaurants. Because this crop is perennial, typically producing buds only after their first year, growing them outside of their naturally mild climates requires a special production step called vernalization wherein seedlings are exposed to artificially cold temperatures to induce bud development. This allows for annual production of artichokes, which are not sufficiently cold hardy for New England winters.

This presentation details management practices and results from three years of annual artichoke field evaluations in Monmouth, Maine. We grew eight globe artichoke varieties over the three years and evaluated three mulching methods. Each year, we used slightly different vernalization methods, which also provided insight as to best practices for ensuring plant productivity.

Each year, seeds were planted into 50-cell trays in March and kept on 75 °F heating mats until germination plateaued. When seedlings had four to six true leaves, they were moved to a cooler to vernalize. Vernalization conditions varied annually based on availability of cold space and ambient field conditions, but 10 days was considered the minimum length of cold exposure. Once seedlings were removed from coolers, they were transplanted within three days into black plastic mulched, raised beds at 24" apart within beds that were 6' on center. 500 lb/ac of 10-10-10 fertilizer was applied at bed preparation, and supplemental fertility was supplied via drip fertigation as needed throughout the season. In mulch trials, the black plastic was removed from appropriate plots and replaced as needed with straw mulch (2021 only), reflective mulch (2022 and 2023), or left bare (all years).

Variety trial plots each contained 12 plants and data were collected from the central 10 plants. Mulch trial plots contained seven plants each, and data were collected from the central five. Bud development began in mid- to late August each year and trials were harvested on a weekly or biweekly basis, as needed to keep up with production patterns. Marketable buds were sorted into size classes and each was then weighed. Classes were set according to USDA standards: 3 -3.5" diameter, 3.5 - 4, 4 - 4.5, and > 4.5. Together, these classes made up a "large" category, indicating that we thought they could be sold individually. A "very small" size class was added for those under 3" in diameter because we thought these also had potential for local markets. Harvests continued each year until either a hard freeze or when the majority of buds became unmarketable. Culled buds were grouped and weighed, and reasons for unmarketability was noted.

Vernalization

Vernalization had an overriding impact on artichoke production. Successful vernalization (the proportion of plants that produced any buds) ranged from 3 to 100% across three years and eight varieties. The details of each year's vernalization conditions are shown below.

Table 1. Vernalization details for three years of annual globe artichoke experiments in Monmouth, Maine.

	2021	**2022**	**2023**
Location	walk-in cold storage	lab refrigerators	plant cooler
Duration (h / d)	336 / 14	303 / 12.6	550 / 23
Temperature (°F)	40	44 / 36 *	42

*Respective temperatures for variety and mulch trials

Seedlings were vernalized for 13 to 23 days, at temperatures ranging from 36 to 44 °F, and with and without supplemental light – all depending on the trial year. We found duration to be the most important factor contributing to successful plant vernalization, where in 2023, the year with the longest vernalization period, upward of approximately 90% of plants flowered for all but one cultivar (Figure 1).

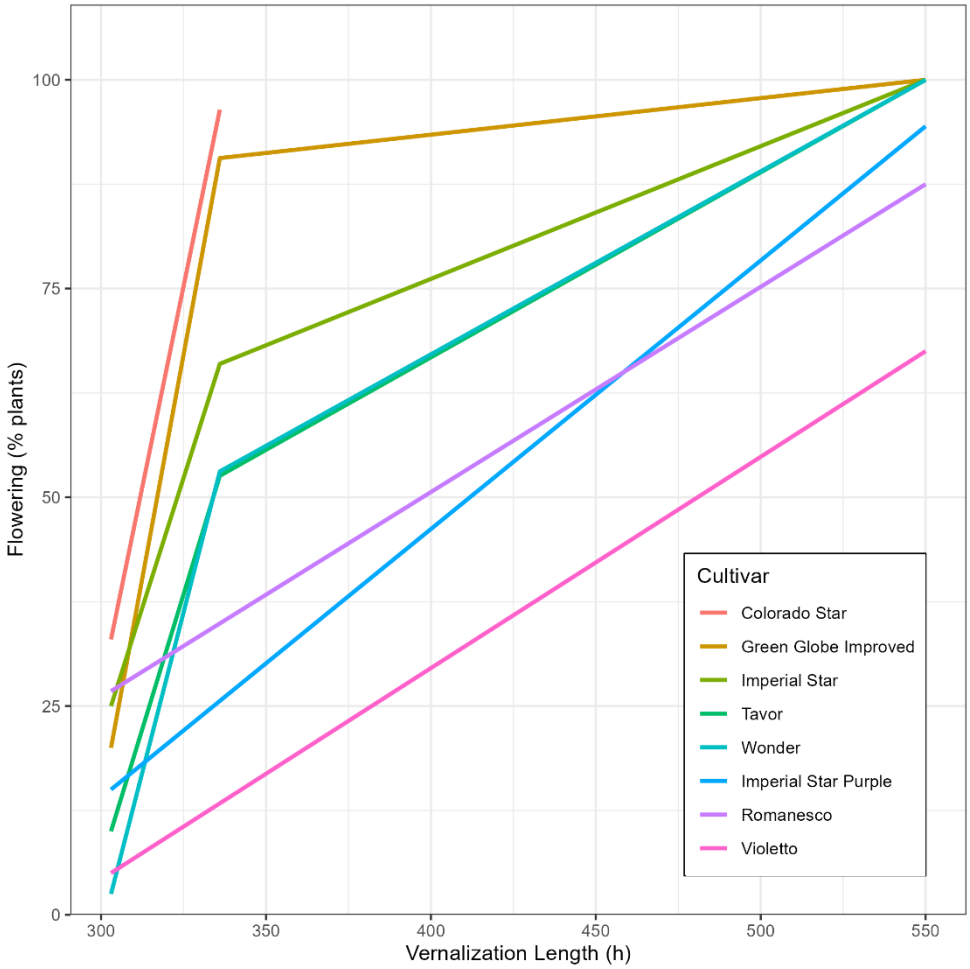

Figure 1. Relationship between vernalization duration and proportion of flowering plants.

Yield

Each artichoke plant typically produces one to three flowering stalks per year. The terminal bud, often called a "primary", is the largest, and those produced from axials further down on the stalk are successively smaller and referred to as "secondaries", "tertiaries", etc. We found that usually only terminal buds are greater than 3" in diameter and therefore individually saleable. The vast majority of what a plant produces, by number and weight, is derived from the many smaller buds produced after the primary.

We measured yield on a "per flowering plant basis" to reflect the potential for improving yields with improved vernalization. By this standard, yields ranged from 170 to 882 g per flowering plant. Green Globe Improved, Tavor, and Wonder produced high yields of relatively high-quality buds, while purple cultivars performed poorly.

Plants grown on bare ground underperformed those grown on black and reflective mulches. Because reflective mulch did not deter pests as expected, standard black plasticulture was found to be most conducive to productive plants.

Key Take-Aways:

- Adequate vernalization plays a major role on artichoke yields in annual systems. Exposing seedlings to 35 to 50 °F for approximately three weeks should provide sufficient chill hours for reliable flowering rates.
- While the use of standard black plastic may induce devernalization in sensitive varieties, sufficient vernalization (see above) might mitigate this effect. This proved to be the most cost-effective and productive approach for artichoke culture in our research.
- Results from our work show that with sufficient vernalization, Green Globe Improved, Tavor, and Wonder can be expected to produce good yields in New England. Purple varieties such as Colorado Star and Violetto are likely to produce low yields. Imperial Star and Imperial Star Purple produced variable yields and high cull rates.
- Ensure that your markets will be receptive to artichokes less than 3" in diameter, as this size class comprises the bulk of production in this type of growing system. Consider marketing these very small artichokes by weight and/or volume.

Please contact Peyton Ginakes at peyton.ginakes@maine.edu or (207)933-2100 with any questions or comments about this project or general artichoke production. Up-to-date research reports can be found at the University of Maine's Highmoor Farm website: extension.umaine.edu/highmoor/resources-by-crop/ .

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Growing Organic Herbal Teas

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Pork Hill Farm has been in operation since 2009. We grow certified organic vegetables, flowers, and herbs for our CSA, farm stand and wholesale customers. In 2021 we increased our cultivation of both medicinal and culinary herbs in an effort to add an additional revenue stream to our farm. Over the past three years, we have continued to expand our production of both perennial and annual herbs, culinary and medicinal, and have started to dry, process and blend these herbs for teas which we sell through our farm stand and other retail locations. Increasing herb production has had a number of benefits for our farm. We have reduced tillage through perennial and long season plantings and created new pollinator habitat, attracting many native bees, butterflies, and beneficial insects. We have also created an additional revenue stream for the farm by drying and processing our herbs into teas, which has given us a shelf stable product that we can sell throughout the year. While we grow over thirty different culinary and medicinal herbs, our current production for herbal teas focuses on Calendula, Chamomile, Tulsi / Holy Basil, Echinacea, Mint, and Lemon balm. This mix of herbs works well for us in terms of production, harvest, yield, processing, and marketability. They are also beautiful and a joy to grow.

Echinacea purpurea - Echinacea is a perennial that has been traditionally used to support the immune system and makes a wonderful tea. Echinacea attracts many native bees and monarch butterflies. It is easy to grow, dry and process. We start Echinacea seedlings in the Spring and transplant them into the field after the danger of frost has passed. We plant Echinacea in beds 3 across at 12-14 inches. This spacing is closer than recommended, but we have found it works well for us. We harvest the leaves and flowers for teas in the second year of growth, usually harvesting only about 1/4 of each plants aerial parts. In the third or fourth year, we dig Echinacea roots to dry and process, following with compost and a cover crop like Red clover, which we also dry for teas. We add Echinacea leaves and petals to our tea blends and we are currently working on a straight Echinacea tea which incorporates leaves, flowers, and roots blended together.

Calendula officinalis - Calendula is a long season annual, that adds beauty and attracts pollinators to the farm, and has a number of traditional benefits and medicinal uses. We add Calendula to our tea blends for its bright color and vibrant taste. Calendula usually begins to flower in June and will continue into October, although the harvest is most bountiful in July and August. We start Calendula seedlings in the Spring and transplant out after the danger of frost has passed. We plant Calendula 3 across with 12-14 inches between plants into composted, prepped and mulched beds with drip irrigation. This planting is closer than recommended, but we have found it works for us. Calendula responds well to being harvested - the more you harvest, the better the yield. Calendula is easy to grow, but a bit trickier to dry, needing approximately eight days for the flowers to become completely dry and ready to store. We check the flowers frequently through the drying process.

Chamomile, Matricaria recutita- Chamomile, a prolific annual, is widely recognized for its calming and relaxing properties, and is one of the most popular herbs we grow. We start Chamomile seedlings in the Spring and transplant out into the field after the danger of frost has passed. We plant Chamomile 3 across about 12 inches apart in composted, prepped, and mulched beds with drip irrigation. We begin to harvest Chamomile in late June, usually once a week for about 5-6 weeks. We use a chamomile rake, as well as harvest by hand. We find that keeping the flowers whole lends more beauty, flavor, and aroma to our tea. We use Chamomile as a single herb tea, as well as in blends. Chamomile dries quickly and is easy to process as we leave the flowers intact. We check Chamomile frequently throughout the process to prevent over drying.

Lemon balm, Melissa officinalis- Lemon Balm is a perennial on our farm, but we start new seedlings most Springs. This gives us a few beds to harvest from each year - some we harvest early for vibrant new growth, while others we harvest later, in bloom, in an effort to capture additional benefits and volatile oils. We plant Lemon balm 2 across with about 18 inches between plants in composted, prepped and mulched beds with drip irrigation. Lemon balm yields well, but can be trickier to dry as it is is subject to overheating, so special attention must be given during the drying process. We like to start Lemon balm off at a low heat for the first day or so and then increase the temperature to around 90 degrees to finish the drying process. Starting Lemon balm at a lower heat and increasing the temp slowly can help prevent browning while keeping the leaves feeling fresh, green and fragrant. Lemon Balm adds a delicious flavor to our tea blends and is also wonderful and vibrant on it's own.

Mint, Mentha piperita - Mint is popular perennial herb, known for its cooling and digestive properties. Mint is easy to grow and makes delicious, marketable teas. We propagate mint from cuttings from our existing plants, which we cut in the field and transplant directly into composted and prepped beds with drip irrigation. We plant Mint 3 across with about 12 inches between plants. Mint grows into a dense bed with little weed competition. We mow walking rows around Mint to prevent it from spreading beyond the bed. We also pick beds closer to the edges of the field for our Mint plantings. We harvest Mint selectively throughout the summer for fresh herb sales, and then fully harvest once Mint begins to flower in late summer, leaving the bottom 1/3 of the plants for regrowth. Mint can be tricky to dry and is subject to overheating. For this reason, we start Mint at a lower temperature to allow moisture to leave the plant slowly, increasing the temperature after 24 hours or so. This method helps us prevent browning and keeps the Mint leaves green, vibrant, and fresh. Mint dries quickly and should be checked often throughout the drying process.

Tulsi/ Holy Basil, Ocimum tenuiflorum - Tulsi, also known as Holy Basil, is one of our most favorite plants to grow. Aside from making delicious and restorative tea, it offers abundant forage for honey bees, bumble bees, and a plethora of native pollinators while adding beauty to the farm. Tulsi's scent alone can uplift the spirit, and it is a joy to work with. We start Tulsi in the Spring and transplant seedlings into the field after the danger of frost has passed. We plant Tulsi 2 across or 3 across and with 12 or 18 inches between plants depending on the bed. Tulsi is planted into composted, prepped and mulched beds with drip irrigation. We begin to harvest Tulsi once the plants have bushed out and are flowering. We like to harvest Tulsi before the flowers set seed, harvesting half of the aerial parts of the plants (flowers, leaves and stems) and leaving half for regrowth. In a good year, we will harvest Tulsi every 3 weeks, getting at least 5

harvests per bed, per season. Tulsi can be tricky to dry and dries slower than other herbs. We like to start Tulsi off at a low heat to prevent browning. After a few days we will increase the heat temperature to 95-100 degrees, and continue to dry for a week, sometimes a little longer depending on the weather.

We use a 12 ft X 16 ft greenhouse sheathed in rigid plastic for our drying facility. We cover this greenhouse with a heavy duty tarp and dry our herbs in total shade. This helps the herbs retain their color, quality, volatile oils and medicinal properties. We use our greenhouse heater, automatic ventilation system, and additional fans to regulate the drying process. We also use a dehumidifier to remove the moisture given off by the plants during drying, which assists in the drying process. Once dried, we process our herbs, typically removing leaves from steams by running the plants over a piece of hardware cloth and abrading them by hand. We keep flowers intact and whole. From here the dried plants move to storage which is kept at an even 50 degrees, and we blend our teas throughout the the year.

Incorporating culinary and medicinal herbs into the farm has been a wonderful direction for us. Growing herbs feels rewarding and joyful and positive for the farm and the pollinators. Creating high quality teas from these herbs is a fun and creative process, while also adding additional revenue to the farm throughout the year. There are a couple great resources that we refer to as guides for helping us to grow, process, and learn more about the amazing qualities of herbs. *The Organic Medicinal Herb Farmer*, written by Jeff Carpenter and Melanie Carpenter of Zack Woods Farm has been an invaluable resource for us, along with *The Healing Garden*, by Deb Soule of Avena Botanicals. These books can provide you with more information and inspiration about working with herbs.

Ginger & Turmeric Production - Grower Panel

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Growing ginger and turmeric in unheated high tunnels in the Northeast can a be a valuable addition to a diversified vegetable farm. At Roots Farm, we have grown ginger and turmeric commercially for over 10 years, and use a combination of strategies including pre-sprouting, appropriate soil moisture, plant spacing, cultivation, hilling, soil fertility, and timing to achieve high quality and profitable yields of fresh baby ginger and turmeric in our unheated moveable high tunnels.

Seed

We source our ginger and turmeric seed through Hawaiian Clean Seed. We have trialed another supplier for ginger, but found it to thus far have slightly lower yields, be unreliable in quality, and a hassle to acquire. The money saved on seed cost was not worth the uncertainty for such a high value crop for our farm. We aim to have seed ship by early March, as that timing works best for the desired soil temperatures that the rhizomes need for transplanting after pre-sprouting.

The rhizomes are cold sensitive, and do not want to be below 60F if you plan to plant them. Since they ship in winter, we make sure we are around for delivery to bring them indoors right away, even though we may not start to pre-sprout them for another few days.

Prior to pre-sprouting, we cut the ginger rhizomes using a frequently sanitized knife. For turmeric, we simply snap off "fingers", so no knife or sanitizing is required. After cutting seed, we allow them to air cure for 1-3 days.

Pre-sprouting

Pre-sprouting has been a critical step to ensure profitable yields for us, and often when talking with other growers this is a step that is missed or not done sufficiently. The following is an outline of the key steps in our pre-sprouting process:

- Warm Vermont Compost's Fort Vee potting mix to at least room temperature. (Avoid putting the rhizomes in cold potting mix.)
- We use two nested 1020 trays for each flat of rhizomes. We place a solid 1020 tray (with small drainage holes) inside a mesh 1020 tray. By putting a mesh tray under a solid tray (with small drainage holes), it gives the flats structural support for handling, as they can be heavy when full and moving between locations.
- Fill each flat halfway with the warm Fort Vee potting mix.
- Place rhizomes on top of this half layer, ideally 0.5-1.0 in. between each rhizome. We cover the rhizomes with more potting mix until flats are full to near the top.
- We set the flats in our sprouting chamber, which we built with 2x4s for the frame and shelves and pink insulation panels for walls. We use between 2-3 small space heaters and

small fans to ideally maintain a soil temperature of 72 – 75F. We have found that turmeric is a little slower to sprout than ginger, and wants to be more near 77F.

- We water the flats every two days with a long, skinny-necked watering can that can fit in the tight space between the shelves. Proper soil moisture is key – too wet can cause rot, but too dry will halt the sprouting process.
- Shortly after the rhizomes send shoots up above the soil line, we move the flats to our propagation tunnel, as our germination chamber does not have light. We have found that the shoots are sensitive to bright sunlight right after coming out of the chamber, so we will partially shade them for 1-2 days upon moving them. We also top off the flats with more potting mix to keep the rhizomes covered if any are exposed at this stage. (We have found that rhizomes exposed end up less vigorous.)
- We keep the flats at ~70F on heated tables until transplanting. Once in the propagation house they are watered at least once a day, as being in the sun will dry out the potting mix faster than in the germination chamber.
- Note: We advise against pre-sprouting inside your house if you have houseplants – we attempted that years ago before we had sufficient heated germinating space, and found that spider mites had heavily damaged our rhizomes, likely coming in from our houseplants.

Transplanting

We time the transplanting of the rhizomes for a combination of (1) when the soil temperature in our high tunnels is at least 60F, although 65-70F would be better, and (2) when we have time to do so. Once they have sprouted, we try not to have them stay in their flats more than one month. However, we have found that ginger and turmeric are more flexible on their transplant timing than crops such as tomatoes or cucumbers, so we are always able to prioritize the other high tunnel crops first. Generally we plant our rhizomes in late May or early June.

We amend the soil in our moveable high tunnels similar to other heavy feeder crops such as tomatoes and cucumbers, and utilize a no-till, permanent bed system. For both ginger and turmeric we plant one row per bed on a 30 in. bed top. We make a 2-3 in. deep furrow down the center of the bed with a wheelhoe trench attachment. For ginger we use a 4-5 in. spacing (about one “hand” width). For turmeric we use a slightly larger spacing of 5-6 in. (about one hand plus another finger width). We always plant the best rhizomes with the most vigorous shoots. We cover the rhizomes and trench with soil using a rake after planting. We irrigate with two drip lines down either side of the row, generally irrigating every two days for 90 min.

We plant ginger in two different settings: (1) “full sun” in a high tunnel that has 30% shade cloth during the summer months, and (2) in shadier, northern beds of tomato high tunnels. The ginger in (1) “full sun” (not behind the tomato beds) has always performed better than those in (2) shaded by tomato plants. The turmeric is a taller plant, so we have always planted it in more central beds of high tunnels, thus have not compared the effect of crop shading on turmeric.

Cultivation & Hilling

We generally use a collinear hoe when cultivating ginger and turmeric, but also use the hoe to hill the rhizomes, similar to potatoes but slightly less so. We aim to hill them 3 times per season.

Harvest & Sales
We start checking the ginger rhizomes in late August. We aim to get a minimum of 1.0 lb/bed-ft for yield. If the yield is lower, we often wait another week or two before starting to harvest. Turmeric takes longer to achieve our goal of 1.5 lbs/bed-ft, so we usually begin harvest in late September.

We calculate the yield in pounds per foot at each harvest so that we can track how the crop is doing, and decide if we want to harvest more or less for our markets. The decision on target harvest is based not only on yield, but on market demand and number of weeks left before frost. Our goal is to sell all of the baby turmeric and ginger fresh and to not have to freeze it. We have found a much higher demand for fresh, and thus prefer not to have to manage frozen items at our CSA pickup or farmers markets. Each year we fine tune the ginger and turmeric planting plan to best match supply with demand for our sales outlets.

We harvest the rhizomes with a D-handle fork. We cut the tops and roots off, then wash the rhizomes well. We find that the ginger and turmeric sell much better if they are shiny and clean at our markets. We do not sell our ginger or turmeric with tops/leaves attached. Occasionally we may bring leaves to markets for interested customers, but there is not much demand on a consistent basis. Additionally, given the higher pricepoint for our fresh baby ginger and turmeric, we do not want to charge for the weight of the leaves.

Final points
Each season we grow approximately 250 and 80 bed-feet of ginger and turmeric, with yields averaging 1.2 and 1.8 lbs/bed-ft, respectively. Our retail prices for fresh baby ginger and turmeric are currently $20 and $22 per lb, giving us a crop value of $24 and $39 per bed-foot. Although the ginger yield is lower than turmeric, and even lower than our high tunnel tomatoes, it is a relatively low labor crop, so is well worth the high tunnel real estate, considering our customer demands and our balance of crop offerings.

Ginger and Turmeric Production - Grower Panel

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Rustic Roots Farm SARE Ginger Study Results:

In this study, we measured (1) harvested ginger by weight (oz) and (2) ginger growth increase (%) in relation to seed spacing in both in-ground research beds and fabric research containers. The overall goal of this project is to determine ideal spacing for maximum yield based on a combination of these two values.

In our 2021 research beds, seed ginger was planted in four 25' plots: 8" single row, 4" single row, 8" double row and 4" double row. The least intensive planting, 8" single spacing produced the least total harvested ginger by weight (310.24oz) and the greatest growth increase (+569%). Conversely, the most intensive planting, 4" double spacing, produced the greatest harvested ginger by weight (690.24oz) and the least growth increase (+272.22%). By comparison, the two intermediate planting rates resulted in more similar results: 4" single spacing produced 476.8oz of harvested ginger and 414.24% growth increase; 8" double spacing produced 615.68oz by weight and an increase of 564.02%. It should also be noted that the latter two spacing methods contained a near equal weight of initial seed ginger.

In our 2021 research containers, seed ginger was planted in fifteen 20 gallon fabric pots at a rate of 5 containers each of 1 seed, 2 seed or 4 seed. Pots were randomly arranged. The total harvested ginger by weight ranged from 4.96oz to 34.72oz and the average growth increase of all containers was 923.63%. Of the five containers containing 1 seed, three resulted in a growth increase greater than the average, one resulted in less than the average, and one pot failed completely. For the containers planted with 2 seed, one resulted in below the average whereas four were above average. All five containers with 4 seed resulted in growth increases below the average.

2021 in-ground ginger harvest (avg seed size = 1.16 oz)			
	Planted (oz)	**Harvested (oz)**	**Growth Increase (%)**
8" Single Row	46.36	310.24	569.20%
4" Single Row	92.72	476.8	414.24%
8" Dbl Row	92.72	615.68	564.02%
4" Dbl Row	185.44	690.24	272.22%
TOTAL	**417.24**	**2092.96**	**416.82%**

2021 container ginger harvest (avg seed size = 1.15 oz)			
	Planted (oz)	**Harvested (oz)**	**Growth Increase (%)**
Container #1	2.32	19.52	741.38%
Container #2	4.64	34.24	637.93%
Container #3	2.32	27.2	1072.41%
Container #4	4.64	34.24	637.93%
Container #5	1.16	17.28	1389.66%
Container #6	1.16	0.112	-90.34%
Container #7	2.32	33.76	1355.17%
Container #8	2.32	29.76	1182.76%
Container #9	4.64	25.28	444.83%
Container #10	1.16	22.24	1817.24%
Container #11	4.64	21.44	362.07%
Container #12	1.16	4.96	327.59%
Container #13	2.32	34.72	1396.55%
Container #14	1.16	23.36	1913.79%
Container #15	4.64	35.52	665.52%
TOTAL	**40.6**	**363.632**	**923.63%**

IPM for Arthropod Pests of Solanaceous Crops

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Colorado Potato Beetle (CPB): The Colorado potato beetle is a significant pest of solanaceous crops, including potatoes, eggplants, and young tomatoes. It overwinters as an adult, typically in soil near host crops, although some may be found in field soil. In spring, these beetles emerge to search for food, favoring the edges of non-rotated fields, where they can cause substantial feeding damage. In northern New England, CPB has one generation per year, while southern New England experiences two. Both adults and larvae are voracious feeders, leading to heavy defoliation that can severely impact young plants. Potatoes can tolerate 15-20% defoliation without significant yield loss when mature, but eggplants are more vulnerable; CPB damage affects leaves, flowers, and buds, directly reducing fruit set.

Scouting and Management: Regular scouting is essential. If using products targeting larvae, monitor for egg hatching and apply controls before larvae reach the third instar, as the fourth and final larval stage is responsible for 85% of feeding damage. For treatments targeting both adults and larvae, assess both life stages to guide your management strategy. Threshold tables and detailed scouting information can be found in the New England Vegetable Management Guide (https://nevegetable.org/crops/potato/insect-control) for both potato and eggplant.

Cultural Controls: Crop rotation is critical in managing CPB; ideally, rotate to a field at least 200 yards away from previous solanaceous crop sites. Natural barriers such as roads, rivers, hedgerows, and non-host crops can slow beetle colonization and lower population pressure. Mechanical methods like trap crops, trench traps, and straw mulch can also help manage infestations. Late potato plantings may suffer fewer beetles, as adults tend to migrate to overwintering sites in August.

Natural Enemies and Resistance Management: Natural predators of CPB include the twelve-spotted lady beetle, spined soldier bug, carabid beetles, and certain tachinid flies. However, CPB can quickly develop resistance to insecticides, sometimes within a year and within individual field populations. Rotate insecticide classes to manage resistance effectively—avoid using the same chemistry or insecticide group more than once per year and do not treat successive generations with the same IRAC group. Resistance to pyrethroids and neonicotinoids is documented in New England. Combining non-chemical methods (cultural and biological) with targeted pesticide applications yields the best results. Effective control in June will help safeguard crops throughout the season and reduce the overwintering population for the following year.

Two-Spotted Spider Mite (TSSM): The two-spotted spider mite is a prevalent pest of vegetable crops in New England, particularly affecting eggplant. These mites damage plants by extracting fluids, leading to mottled or dull bronze leaves, covered in webbing. Other symptoms of

infestation include distorted leaves, stunted growth, loss of vigor, and yellowing. TSSM thrives in hot, dry, and dusty conditions, which can intensify plant stress and injury. Damage may initially go unnoticed, as mites are often hard to detect without close inspection. All life stages of TSSM can survive New England winters, especially in high tunnels.

Management Strategies: Wet weather and overhead irrigation can help reduce TSSM populations. To mitigate risks, avoid weedy fields, over-fertilization, and planting eggplant near legume forage crops or dusty roads when possible. Regular scouting is crucial; look for signs of feeding damage and webbing, using a 10-15X hand lens to identify the mites. Avoid broad-spectrum insecticides, as they can harm beneficial insects and lead to mite flare-ups. Most miticides require two applications, spaced 5-7 days apart, to effectively control immature mites that may attach between treatments (except for bifenazate, which has a long residual effect). Alternating products helps prevent or delay pesticide resistance. Organic options, such as insecticidal soaps and oils, are also available.

Biological Control: Consider releasing predatory mites to help suppress TSSM populations. Preventative releases of ***Phytoseiulus persimilis*** can be effective in strawberry fields and may also work for solanaceous crops, but they are most effective when mite populations are low. Another useful predator, ***Amblyseius fallicis***, is commonly used in greenhouses for TSSM control. For more detailed information on biological control for vegetable transplants, refer to the Vegetable Transplant section of the New England Vegetable Management Guide (https://nevegetable.org/vegetable-transplant-production/transplant-insect-and-mite-management)

Broad Mite: Broad mites are a growing concern for growers, particularly in pepper crops within greenhouses and high tunnels. These tiny pests are adept at hiding in plant material and soil, making early detection challenging. Often, infestations go unnoticed until significant damage has occurred. Symptoms of broad mite feeding include distortion and stunting of new growth, which can easily be mistaken for plant diseases, herbicide damage, or environmental stress. If left uncontrolled, broad mites can cause severe fruit scarring and lead to substantial crop loss.

Control Strategies: Broad mites belong to a different group than spider mites, requiring different control measures, particularly regarding miticide effectiveness. Infestations can result in extreme damage, and in some cases, crop destruction may be the only viable option, especially during fruiting stages. Therefore, prevention and early intervention are crucial. With regular application, sulfur can be moderately effective against broad mites. One New Hampshire farm found success by rogueing heavily infested pepper plants and applying abamectin repeatedly to less infested plants. Thorough coverage is essential for effective mite control. For specific products that target broad mites on vegetable transplants, refer to the Vegetable Transplant section of the New England Vegetable Management Guide (https://nevegetable.org/vegetable-transplant-production/transplant-insect-and-mite-management)

Biological Control: Biocontrol can be effective if implemented early and consistently. Predatory mites such as ***Amblyseius swirskii***, ***Neoseiulus (Amblyseius) californicus***, and ***Neoseiulus (Amblyseius) cucumeris*** have shown promise in managing broad mite populations. Repeated biocontrol releases and biopesticide applications may be required until plants reach maturity.

When combining biological and chemical controls, ensure there is adequate time between foliar chemical applications to minimize non-target effects.

Potato Leafhopper (PLH): Potato leafhoppers are a significant pest affecting solanaceous crops, legumes, and others, with significant damage occurring in potatoes, eggplants, and beans. These pests overwinter in the southern U.S. and migrate northward on storm fronts in early to mid-June. Adult PLHs are wedge-shaped, light green, and take flight when foliage is disturbed, while nymphs are bright green and exhibit a characteristic sideways walk, similar to a crab. Nymphs typically feed on the underside of leaves. Even minimal feeding can lead to significant damage known as "hopperburn." Adults use their piercing-sucking mouthparts to extract plant juices and inject a toxin that clogs plant tissue. This results in yellowing at the tips and margins of the leaves, followed by browning, curling, and eventual death, giving the foliage a crispy or burned appearance. Once hopperburn occurs, it's usually too late for effective control. Rapid browning and dying of potato plants often indicate PLH infestation, although any tubers produced before PLH infestation may remain unaffected. However, yield reductions are likely, especially in later potato varieties. In eggplant, damage may be misidentified as Verticillium wilt, with feeding impacts potentially occurring before visible symptoms appear.

Sampling and Monitoring: To monitor PLH populations, use a sweep net or shake the foliage to observe if adults fly up. For potatoes, treatment is recommended if more than one adult is detected. When scouting for nymphs, check the undersides of leaves and consider treatment if you find more than 15 nymphs per 50 leaves on potato or 1.5 adults or large nymphs per leaf on eggplant.

Varietal Differences and Management: There are varietal differences in potatoes regarding susceptibility to hopperburn. Early-season and red varieties often sustain more damage than long-season varieties. For eggplants, using row covers can effectively protect young plants from PLH, Colorado potato beetle (CPB), and flea beetles. A variety of insecticides are labeled for PLH control; a complete list can be found in the New England Vegetable Management Guide (https://nevegetable.org/crops/potato/insect-control). Some materials effective against Colorado potato beetles, such as neonicotinoid foliar sprays (IRAC Group 4), are also effective against PLH. For organic growers, pyrethrins are the most effective option. Regardless of the chemical used, thorough coverage is crucial since nymphs reside on the underside of leaves.
Inclusion or exclusion of commercial products does not indicate endorsement.

Resources and More Information:

- New England Vegetable Management Guide: Potato-Insect Control (https://nevegetable.org/crops/potato/insect-control), Eggplant-Insect Control (https://nevegetable.org/crops/eggplant/insect-control)
- UMass Extension Vegetable Program Fact Sheets: Colorado potato beetle (https://ag.umass.edu/vegetable/fact-sheets/colorado-potato-beetle), Potato leafhopper (https://ag.umass.edu/vegetable/fact-sheets/leafhopper-potato), Two-spotted spider mite (https://ag.umass.edu/vegetable/fact-sheets/two-spotted-spider-mite)
- Potato leafhoppers. UNH Extension Blog, July 6, 2018: https://extension.unh.edu/blog/2018/07/potato-leafhoppers

- Broad mites in pepper. UNH Extension Blog, May 3, 2020: https://extension.unh.edu/blog/2020/05/broad-mites-pepper
- Eaton, A. 2016. Colorado Potato Beetle. UNH Extension Pest Fact Sheet #16.

Eggplant Evaluations: 2023 Research Report

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Eggplant cultivar evaluation was initiated in 2023 at the University of Maine's Highmoor Farm in Monmouth, ME. Production potential of 12 eggplant cultivars were compared to update Italian-type eggplant cultivar recommendations for commercial growers.

Planting

Eggplant seeds were sown in flat trays filled with Pro-Mix BX with Mycorrhizae media on May 3 (58 days before transplanting) and kept on heating mats at 75 ˚F for 12 days, until germination plateaued. Seedlings were fertilized with 1 Tbsp/gal of Jack's Professional 9-45-15 Plant Starter soluble fertilizer on May 12 (9 days after seeding). When trays were removed from heating mats, seedlings were pricked out individually into 50-cell trays at one seed per cell.

Beds were fertilized with 500 lb/ac of 10-10-10 fertilizer and harrowed on May 31 (30 days before transplanting). Field work was suspended for 30 days due to excessive rain. On June 25, the field was workable and raised beds 60" on center were shaped and covered with 4', 1.5 mil biodegradable black plastic. A single row of drip tape was laid under each bed. On June 26, Gramoxone and Duel Magnum were applied at label rates as preemergent herbicides. Seedlings were transplanted by hand on June 30 (58 days after seeding) 15". Each plot contained 12 plants: 10 data plants and 2 guard plants. The trial was designed as a single factor replicated complete block design with four blocks of 12 cultivars each (Table 1).

Table 1. Attributes of 12 eggplant cultivars evaluated at University of Maine's Highmoor Farm in Monmouth, ME in 2023.

Cultivar	Color	Hybrid Status	Available Organic
Annina	graffiti	F_1	✓
Black Beauty	purple	OP	
Classic	purple	F_1	
Epic	purple	F_1	
Galine	purple	F_1	
Gaudi	purple	F_1	✓
Ghost Story	white	F_1	
Megal	purple	F_1	
Nadia	purple	F_1	
Picasso	purple	F_1	
Thanos	purple	F_1	
Traviata	purple	F_1	✓

Weeds were controlled by hand and with a flame weeder throughout the growing season. Colorado potato beetle was picked from plants by hand August 10 (41 days after transplanting), and Asana XL was applied at label rates to further control insect pests four days later.

Data Collection

Eggplants were harvested seven times, weekly from September 6 to October 16 (68 to 108 days after transplanting). Marketable fruit were harvested and separated into two classes: A) fruit with no blemishes and in excellent condition were classified as fancy for retail and wholesale markets, whereas B) fruit of good but not excellent visual quality were deemed suitable for marketing directly to consumers. The number and weight of fruit in each class were recorded for all plots each harvest. Unmarketable fruit were also harvested and weighed, with reasons for culling noted.

Results

Annina, Gaudi, and Thanos (Fig. 1) were the earliest yielding varieties. Yields of all cultivars except Black Beauty increased sharply at the third harvest on Sep 20 (82 days after transplanting). Thanos produced the greatest marketable yield over the season with nearly five marketable fruit per plant and a very low cull rate (Table 2). Annina, Classic, and Picasso produced the largest quantity and weight of high-quality, fancy fruit that would be suitable for retail or wholesale markets.

Black Beauty and Galine yielded poorly despite large fruit size, due to their high percentage (38% and 61% respectively) of unmarketable fruit. Galine was especially prone to thrips damage, frequently resulting in severe blossom end scarring (data not shown). Ghost Story, a white-fruited cultivar, was the second most prolific cultivar. Producing fruit which tending to be sweeter and less bitter than purple cultivars. However, it produced a significantly smaller quantity of fancy fruit than top-yielding cultivars due to scarring and cracking.

Megal produced significantly smaller, slender fruit while all other cultivars produced eggplant that weighed about or more than ½ pound each. Galine produced the largest fruit, and Classic, Picasso, and Thanos were also all relatively large. Annina, Nadia, and Gaudi were all relatively small-fruited, but produced eggplant of excellent quality.

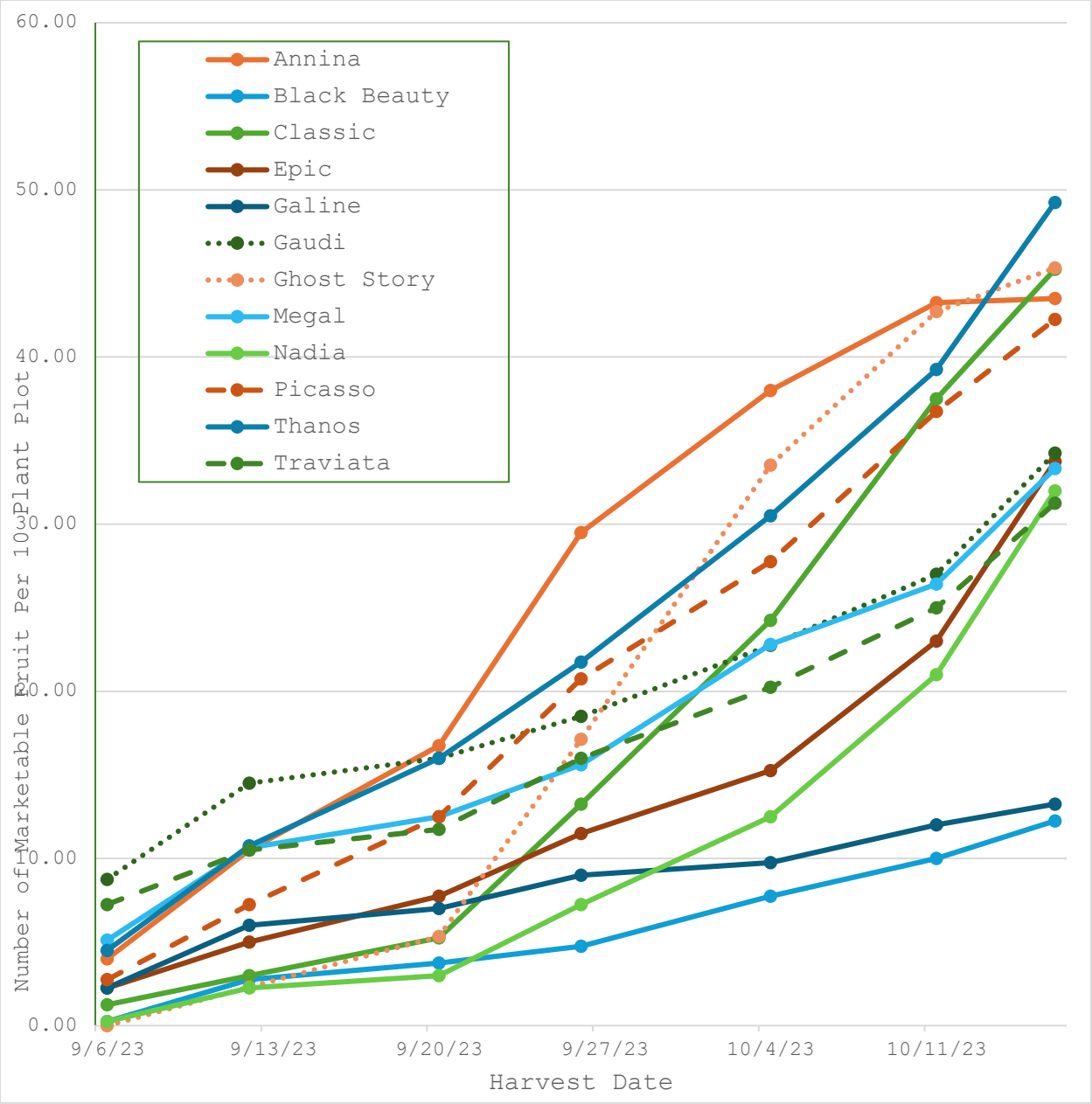

Figure 1. Cumulative marketable yield of 12 eggplant cultivars grown at University of Maine's Highmoor Farm in Monmouth, ME during 2023.

Table 2. Plot yield of 12 eggplant cultivars grown at University of Maine's Highmoor Farm in Monmouth, ME during 2023.

Cultivar	Fancy		Total Marketable		Avg Fruit Wt. (lb.)	Unmarketable Fruit (%)
	number fruit[z]	weight (lb.)	number fruit	weight (lb.)		
Annina	13.75 a[y]	7.33 ab	43.50 ab	22.10 abc	0.52 abc	32 ab
Classic	13.00 a	7.86 a	45.25 ab	27.73 ab	0.61 ab	16 b
Picasso	12.75 a	8.20 a	42.25 ab	26.95 abc	0.63 ab	18 b
Thanos	8.00 ab	5.55 ab	49.25 a	29.94 a	0.61 ab	16 b
Megal	5.78 ab	2.40 ab	33.33 ab	12.28 abc	0.37 c	31 ab
Nadia	5.50 ab	3.14 ab	32.00 ab	15.82 abc	0.49 bc	22 b
Gaudi	4.75 ab	2.35 ab	34.25 ab	17.22 abc	0.50 bc	29 ab
Epic	3.75 ab	2.54 ab	33.75 ab	17.84 abc	0.52 abc	26 ab
Traviata	2.50 ab	1.33 b	31.25 ab	16.75 abc	0.53 abc	25 b
Ghost Story	2.25 b	1.43 b	45.33 ab	23.85 abc	0.51 bc	33 ab
Black Beauty	2.00 b	1.18 b	12.25 b	7.85 c	0.59 ab	38 ab
Galine	2.00 b	1.44 b	13.75 b	9.29 bc	0.71 a	61 a

[z] Yield data are for 10-plant plots.

[y] Values in a column with no shared letters indicate a difference between cultivars at $p < 0.05$.

Acknowledgements

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Please contact Mark Hutton, mark.hutton@maine.edu or (207) 933-2100 with any questions or comments about this research.

High Tunnel Colored Bell Pepper Production at Bardwell Farm

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Bardwell Farm is a 45 acre diversified vegetable farm settled in the Connecticut River Valley, established in 1685. My name is Harrison Bardwell, 9th generation and have been managing the farm as my own for 9 years now after taking the farm out of retirement and started a new chapter of the operation into diversified vegetable production. The farm grows year-round in both open field and protected culture systems. Bardwell farm raises about 25 different crops through the year and we currently sell 75% of our products wholesale and 25% retail at our farmstand. We practice Integrated Pest Management, crop rotation, limited till practices and much more.

As a young famer competing in a saturated market of farmers in Western MA I have taken it upon myself to find ways to stick out in the farming community. I saw colored bell peppers as a fascinating crop, not widely grown in our area and with high demand in our markets. We tried these crops in open fields for 2 years with little success due to the long growth habits of the crop and with the extreme weather events we had experiences leading to fruit rot, drop and plant loss. We decided to trail these peppers in our high tunnel and instantly saw the difference in yield and quality.

Variety Selection: Shorter to mature, good heat tolerant, flavor, uniformity and maturity, plant growth habits

Varieties grown: Red- Red Knight, Sailfish. Yellow- Early Sensation, Abay. Orange- Melina, Delerio

Planting Window: Seeded in Greenhouse Mid-February, transplanted into 30 Cell Trays first week of March. We grow plants early and big because they are going into an unheated tunnel. Planting into tunnel happens Mid- Late April.

Planting Specs: We are subsoiling, tilling, incorporating fertilizer and making raised beds with black plastic in a 200'x30' Tunnel. We dibble holes with a water wheel by hand. Beds are 5ft between each other. We do a double row @ 12" per bed. The tunnel will hold aprox. 2000 plants. All planted by hand

Fertilizer: We base this off the UMAINE HT Soil test. We apply half the needed crop inputs up front at preplant and will do the rest of the fertilizing through drip lines and fertigation weekly until we are on the last fruit set of the crop.

Crop management: Staked Plants every 3 plants, Strings on a basket weave type system run 2-3 times during growth of crops. Manage adequate water and fertility management, heat and climate

of crop during plant growth, flower set and fruit set. These will take a long time before you start harvest, but it is worth it!

Harvest/ Yield: We wait till each pepper is fully turned color before harvest. Harvest is done 2-3 times per week until we end our season. Our harvest time frame runs about 10-12 weeks. In the 2024 season we yielded about 3000lbs of #1 quality pepper off the tunnel.

Sales/ Marketing: We market these as High Tunnel Colored bell peppers, sold wholesale we can charge $3-4 per pound. Typically selling in a 10lb case for $35. Our markets range and weekly volume isn't huge so we sell mainly to local stores and farmstands.

Pros to Grow in a tunnel: We are using the tunnel to grow and manage a very picky crop where we can have better control of water uptake, nutrient, heat/ airflow, humidity and more. In return we can produce a beautiful high-quality product.

Challenges: High heat temperatures can lead to flower drop and loss of fruit set which will lower yields. We struggle with *Phytophthora capsici* in our soils and this is still a problem in our tunnel. Plants breaking stakes, or plants breaking due to growth. Shorter harvest window due to switching tunnels to winter greens the October 1st.

Preventing Yield Loss from Heat Stress in Bell Peppers

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Since 2018 I have been testing the practice of using shade cloth in bell pepper production. Shade cloth is a knitted, weather resistant fabric that can be used to block a portion of the sunlight that would otherwise reach plants. It is commonly used in greenhouse and nursery plant production and could be useful in preventing heat stress in some vegetables. Different colors and levels of shade are available. For vegetables, shade cloth that blocks 30% of the sunlight is typically recommended.

In 2018 and 2019, I tested different colors of shade cloth for green bell pepper production on drip irrigated black plastic mulch. In those trials, the 30% black shade cloth treatment produced the highest yields and increased marketable yield to three times the marketable yield of no shade cloth. Shade cloth did not increase the number of peppers produced, rather it increased pepper fruit size and marketability. Shade cloth can prevent heat stress induced quality defects like sunscald and reduces plant heat stress, resulting in larger fruit. In these trials black shade cloth produced significantly higher marketable weight than the other shade cloth colors (white, red and aluminized).

In the 2018 and 2019 trials the peppers were transplanted in early June and the shade cloth was applied in early July, after the plants had been staked and tied once. Trials conducted in 2020 through 2024 have shown a benefit to applying shade immediately after transplanting in early June. Earlier shading protects young plants from girdling that can result from heat damage to the stem soon after transplanting and help transplants to establish successfully.

In 2021-2023 trials, colored bell varieties and a sweet Italian variety (Carmen) were used. The bell pepper varieties all had significantly higher yields with shade, but Carmen did not have a significant yield increase from shade, indicating that this variety may be more heat tolerant than the bell pepper varieties. One goal of the 2020-2023 trials was to determine the best timing for shade cloth use in peppers. Generally, the treatments with the highest marketable yield were those with shade cloth in both June and July, as opposed to only June or only July. Keeping the shade cloth on for the first two weeks of August increased marketable yield slightly over the June & July shade treatment.

In the 2021 trial I used data loggers to measure air temperatures in the leaf canopy of shaded and unshaded peppers throughout July. Average daily temperatures were 2 °F cooler in the shaded plants. Differences in maximum daily temperatures were even larger, with the shaded plants having, on average, 8 °F lower maximum temperatures. The reduction of maximum temperatures may be especially important in avoiding plant stress and fruit damage from sunscald. Nighttime temperatures under shade were warmer that the unshaded plots, which may be partially responsible for the increased fruit size in shade treatments.

You may be wondering how best to implement shade cloth on your farm. Shade cloth is durable and can be reused for many years. In the experiments described the shade cloth was draped over the pepper stakes and secured to the ground with landscape staples or aluminum tent stakes. Shade cloth can also be applied over low tunnels or larger structures to create “shade houses”. Shade cloth might also benefit high tunnel grown peppers during the hottest months. In my trials we did not remove the shade cloth for sprays and did not notice differences in disease incidence between shaded and unshaded plots. Unless used with a large structure, shade cloth will have to be moved to access plants for tying and harvest.

Variety Performance in Organic Specialty Potato Production

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In 2024, in response to an ongoing assessment of the need for varietal traits among specialty potato producers, a one-year trial of 15 potato varieties was conducted at Rogers Farm Forage and Crop Research Facility in Old Town, Maine. Potato varieties in the trial are either commercially available cultivars or advanced clones from the University of Maine breeding program. According to the 2022 Census of Agriculture most farms producing potatoes in Maine (69 percent) do so on small acreages of 5 acres or less and grow product almost entirely for the fresh market. Fresh market potatoes are commonly sold through direct-to-consumer marketing channels including on-farm markets, farm stands, and farmers markets. Retail channels such as health food stores, grocer co-ops, and regional and national grocery chains are also common market channels for fresh market potato products in Maine. In recent decades, specialty potato products have brought greater choice to consumers by offering unique combinations of size, skin and flesh characteristics as well as placing emphasis on quality and convenience. This study evaluates specialty potato varietal performance under organic production practices and identifies high-yielding specialty potato varieties suitable for farmers who produce potatoes in accordance with the USDA's National Organic Program standards.

In 2024, field trial was planted in a field of silt loam soil classified as Pushaw-Boothbay Complex that had been previously fallowed. Trial site was rototilled and a combination of (K_2SO_4) natural sulfate of potash (0-0-51), bone char (0-16-0) and vegetable and animal protein meals (10-0-0) where top-dressed and lightly incorporated just before planting at the recommended rates according to a soil test report produced by the UMaine Soil Testing Lab. Nitrogen budget was split applied with two-third applied at planting and one-third applied at hilling. Seed tubers were cut into between 1 and 2-oz pieces containing at least two eyes per piece at planting time. Experimental plots were planted on 13 May and 14 May. Seed pieces were planted at 9-in. in-row spacing into 4-in. deep furrows and covered with 2-inches of soil.

Experimental plots are 9-ft by 3-ft and arranged side by side in a randomized complete block design with four replications. Border plots of the same dimensions were placed along all four edges of the trial. Vine emergence counts were taken at 14, 21 and 28-days post planting. Monthly precipitation totals at Rogers Farm during the months of May, June, and July were 2.93, 4.88, and 3.22 inches, respectively. Drip irrigation was applied when necessary to minimize moisture stress. Weeds were controlled using hand cultivation. Colorado potato beetle adult and larval counts consistently exceeded the economic threshold despite integrated control measures which included, applications of Entrust^{TM} at label rates on 21 Jun and 3 July, and continuous hand picking. Senescence of vines in all experimental plots occurred prior to harvest. Experimental plots were harvested on 29 Aug and 30 Aug and stored at 46°F. Potato lots were weighed, sorted by size, and assessed for marketability, post-harvest disease incidence, wireworm damage incidence, and incidence of tuber disorders on 5, 11 and 13 September.

Chieftain (374) – Shoot emergence at 21 days after planting was 83%, and 85% at 28 days after planting. Average percent incidence of late season defoliation was 15.3%. Average incidence of wireworm damage was 27.8%; common scab was 52.6%; black scurf was 41.5%; and growth cracks were 9.7%. Plants produced an average yield of 258.7 CWT per acre, and a marketable yield of 120.9 CWT per acre.

NDAF113484B-1 (425) – Shoot emergence at 21 days after planting was 94% and remained unchanged at 28 days after planting. Average percent incidence of late season defoliation was 27.5%. Average incidence of wireworm damage was 9.4%; common scab was 53.7%; black scurf was 5.3%; and growth cracks were 0.4%. Plants produced an average yield of 181.9 CWT per acre, and a marketable yield of 153.9 CWT per acre.

Baltic Rose (253) – Shoot emergence at 21 days after planting was 67%, and 94% at 28 days after planting. Average percent incidence of late season defoliation was 10.5%. Average incidence of wireworm damage was 14.7%; common scab was 30.3%; black scurf was 34.5%; growth cracks were 1.4%. Plants produced an average yield of 201.3 CWT per acre, and a marketable yield of 138.0 CWT per acre.

Pinto Gold (986) – Shoot emergence at 21 days after planting was 63%, and 94% at 28 days after planting. Average percent incidence of late season defoliation was 52.0%. Average incidence of wireworm damage was 15.2%; common scab was 35.7%; black scurf was 52.5%; growth cracks were 0.4%. Plants produced an average yield of 110.9 CWT per acre, and a marketable yield of 61.2 CWT per acre.

AF7095-4 (531) – Shoot emergence at 21 days after planting was 94%, and 100% at 28 days after planting. Average percent incidence of late season defoliation was 29.2%. Average incidence of wireworm damage was 13.8%; common scab was 20.2%; black scurf was 49.7%; no growth cracks were observed. Plants produced an average yield of 197.7 CWT per acre, and a marketable yield of 144.4 CWT per acre.

Satina (749) – Shoot emergence at 21 days after planting was 94%, and 98% at 28 days after planting. Average percent incidence of late season defoliation was 31.8%. Average incidence of wireworm damage was 18.5%; common scab was 98.7%; black scurf was 0.4%; growth cracks were 1.7%. Plants produced an average yield of 175.5 CWT per acre, and a marketable yield of 108.9 CWT per acre.

AF6868-6 (168) – Shoot emergence at 21 days after planting was 100%. Average percent incidence of late season defoliation was 50.0%. Average incidence of wireworm damage was 16.6%; common scab was 27.1%; black scurf was 6.7%; no growth cracks were observed. Plants produced an average yield of 283.7 CWT per acre, and a marketable yield of 228.7 CWT per acre.

AF6903-3 (692) – Shoot emergence at 21 days after planting was 100%. Average percent incidence of late season defoliation was 63.8%. Average incidence of wireworm damage was 16.3%; common scab was 46.2%; black scurf was 58.3%; growth cracks were 11%. Plants

produced an average yield of 192.9 CWT per acre, and a marketable yield of 105.6 CWT per acre.

NDAF1489-4 (634) – Shoot emergence at 21 days after planting was 90%, and 92% at 28 days after planting. Average percent incidence of late season defoliation was 49.2%. Average incidence of wireworm damage was 4.2%; common scab was 15.0%; black scurf was 15.0%; no growth cracks were observed. Plants produced an average yield of 300.2 CWT per acre, and a marketable yield of 262.0 CWT per acre.

Huckleberry Gold (728) – Shoot emergence at 21 days after planting was 100%. Average percent incidence of late season defoliation was 70.0%. Average incidence of wireworm damage was 18.2%; common scab was 56.5%; black scurf was 6.3%; growth cracks were 5.3%. Plants produced an average yield of 147.9 CWT per acre, and a marketable yield of 103.4 CWT per acre.

AF6575-6 (357) – Shoot emergence at 21 days after planting was 100%. Average percent incidence of late season defoliation was 28.5%. Average incidence of wireworm damage was 12.5%; common scab was 41.0%; black scurf was 25.0%; growth cracks were 1%. Plants produced an average yield of 274.3 CWT per acre, and a marketable yield of 203.8 CWT per acre.

Adirondack Blue (817) – Shoot emergence at 28 days after planting was 50%. Average percent incidence of late season defoliation was 26.0%. Average incidence of wireworm damage was 40.0%; common scab was 44.1%; black scurf was 30.5%; growth cracks were 3.3%. Plants produced an average yield of 130.0 CWT per acre, and a marketable yield of 89.5 CWT per acre.

AF5412-3 (973) – Shoot emergence at 21 days after planting was 100%. Average percent incidence of late season defoliation was 27.6%. Average incidence of wireworm damage was 12.7%; common scab was 70.9%; black scurf was 2.1%; growth cracks were 0.3%. Plants produced an average yield of 220.2 CWT per acre, and a marketable yield of 186.8 CWT per acre.

Purple Viking (195) - Shoot emergence at 21 days after planting was 85%, and 98% at 28 days after planting. Average percent incidence of late season defoliation was 22.7%. Average incidence of wireworm damage was 21.2%; common scab was 96.5%; black scurf was 10.8%; growth cracks were 47.1%. Plants produced an average yield of 163.4 CWT per acre, and a marketable yield of 53.4 CWT per acre.

Amarosa (542) – Shoot emergence at 21 days after planting was 98%. Average percent incidence of late season defoliation was 43.3%. Average incidence of wireworm feeding damage was 16.9%; common scab was 83.2%; black scurf was 9.1%; no growth cracks were observed. Plants produced an average yield of 151.0 CWT per acre, and a marketable yield of 107.4 CWT per acre. No varieties trialed showed any incidence of hollow heart.

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Figure 1. Sample from each of fifteen potato varieties grown in trial plots at Rogers Farm Forage and Crop Research Facility in Old Town, Maine in 2024. Codes on stakes pictured next to tubers correspond with variety descriptions.

Growing Points for Better Brussels Sprouts

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Brussels Sprouts are a popular vegetable with consumers, but they can be a bit tricky to grow. Brussels Sprouts are best grown in areas with a mild climate, like the maritime climates of Northern Europe. Belgium is a large producer of Brussels Sprouts, with a large freezer industry exporting Brussels Sprouts around the world, including the USA.

Our climate in the Northeast is mostly continental, and this presents challenges to growing high-yielding crops of Brussels Sprouts with high quality. Stressors, like heat, drought, excessive rain, etc. can cause fluctuations in the rate of growth of crops. This is a particular problem for Brussels Sprouts, because any dormant or no-grow periods during stress mess up the hormonal system that regulates plant growth. The growing point at the top of the stem (apical meristem) suppresses the development of the lateral buds (sprouts) during plant development until later in the season when the plant is mature. Ideally, the plant grows actively at a moderate pace throughout the season, resulting in tall and sturdy plants with evenly sized sprouts from the bottom to the top of the plant.

In reality, stress during the growing season sometimes halts the growth of the plant. At this point, the top bud is no longer producing the hormones that suppress the development of the lateral buds, and the lateral buds begin to develop pre-maturely when plant growth resumes after the stress is alleviated. This results in very large sprouts at the bottom of the plant, and tiny sprouts at the top. Sometimes the lower sprouts grow out into additional stems that carry their own Brussels Sprouts, but more often the lower sprouts “blow out”, get “funky” and overrun with Alternaria (black spots and smudges). It is important, therefore, to avoid stress to the crop as much as possible and create conditions for even (but not excessive) growth.

Fertility

Brussels Sprouts will use roughly 200 – 250 pounds of N per acre, 200 – 300 pounds of K, and 60 – 100 pounds of P. Adjust as needed based on soil tests, cover crops, green manures, etc. The bulk of fertility should be applied at planting time. This will encourage the plants to grow quickly and make a tall stem before the worst of summer heat stress slows down plant growth. No major side-dressing after July.

The plants will need to run out of fertility by the end of the crop cycle. This forces the plants to draw nutrients from the leaves to develop the sprouts. Ideally, the leaves will yellow and shed from the plant, leaving a bare stem with green sprouts.
Too much fertility will prevent leaves from shedding, making harvest more difficult and delaying crop maturity. Too little fertility will stunt plant growth and produce weak plants and sprouts with yellow wings (wrapper leaves of the sprouts). It takes time to read your ground and learn how the crop responds to fertility. Nitrogen is the driver of vegetative development, so you can

use Nitrogen to help the crop along or you can withhold nitrogen if the crop is too lush. A little nitrogen can help to "freshen up" the crop late in the season to green up the sprouts, if necessary.

Irrigation
We are all familiar with Blossom End Rot in tomato and pepper. In Brassicas we often see tipburn, which is caused by the same lack of Calcium transport to the young and developing tissues during periods of rapid growth when there is not enough soil moisture for plants to take up enough water to sustain evaporation through the leaves and also supply moisture and nutrients to young tissues.

Tip burn in Brussels Sprouts often happens in the lower sprouts. Calcium deficiency causes tissues to collapse later in the season, and these weak and collapsing tissues are quickly colonized by Alternaria, and sometimes soft rot bacteria. The result is "funky" sprouts.

Fungicides will not be very effective at preventing these funky sprouts. Instead, prevent calcium deficiency issues by irrigating Brussels Sprouts the same way you would vine crops, lettuce, tomatoes. Just because the Brussels Sprout plants don't quickly show signs of wilting does not mean that they are not drought stressed.

Variety selection
There are several good varieties of Brussels Sprouts on the market. In general, hybrid varieties have more vigor than OP varieties. Vigorous varieties have more power to grow through the stressful periods of the season and tend to make stronger plants that ultimately produce better sprouts.

Bejo recommends SILVIA for early harvests of medium sprouts with high quality, MARTE and DAGAN for early main season of medium-large sprouts, and NAUTIC for later harvest of medium sprouts.

Timing of planting and harvest
Planting early will give the plants plenty of time to put on some good growth before the heat of summer and will result in more yield. However, when the sprouts become overmature they tend to "bloom out" and become poofy, so the lower sprouts may not be marketable while the top sprouts will have decent size. Planting late will prevent the lower sprouts from getting funky, but the top sprouts will be (too) small.

In our own trials, we find that planting in mid-late June results in a nice balance of yield and quality for harvest in late October.

Covering Ground: Interseeded Cover Crops in Late Season Cabbage

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Due to the short growing seasons in Northern New England, cash crops are often harvested too late to establish a cover crop after harvest and prior to the winter. This study aimed to evaluate the effects of different interseeded cover crop planting dates and cover crop planting methods on cabbage yield, cover crop biomass, and weed biomass. The research was conducted to provide evidence-based recommendations to farmers in the Northeast region who interseed or intend to interseed cover crops over cabbage cash crops now or in the future. In addition to our research-farm based replicated trials, we worked with collaborating farms to trial this practice with a number of different cabbage production approaches and available equipment.

MATERIALS AND METHODS

Cover Crop Timing and Seeding Methods

Treatments: (a) timing of seeding in relation to the cash crop seeding date (main-plot treatment), and (b) seeding method (subplot treatment). Our timing treatment (a) includes planting a cover crop of annual ryegrass and crimson clover mixed (25 lb/A 60% ryegrass:40% clover), at 10, 21, and 30 Days After Transplant (DAT) with an additional post-harvest cover crop planting date serving as a control. The post-harvest plots were weeded throughout the growing season. Within those treatments, we tested the effects of different planting methods (b); broadcasting seed, broadcasting and incorporation using a hand rake, and drilling the seed between crop rows with an Earthway® push seeder.

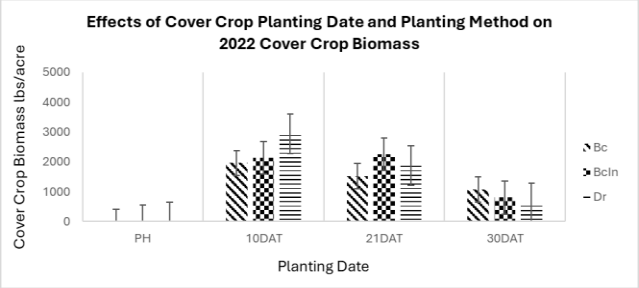
RESULTS AND DISCUSSION

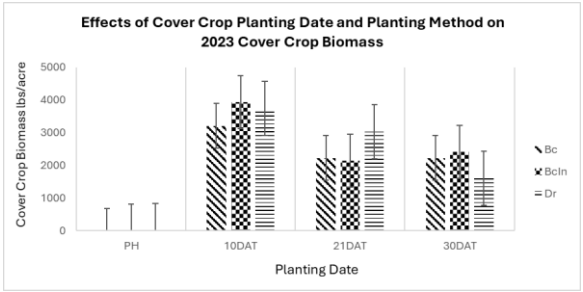
Cabbage Yield

In 2022, there were no statistical differences in cabbage yields between all planting date treatments. In 2023 the control plot (Post-Harvest) yielded significantly higher than the 10DAT plots. 2023 was a particularly wet growing season, which provided the resources for excessive cover crop and weed growth. This yield difference could be due to no competition with cover crops or weeds for nutrients in the control plots, and excessive competition for resources (including sunlight), and reduced airflow, particularly in the 10DAT plot. This decline in yield at later dates suggests that waiting for cabbage to develop before seeding cover crops would result in decreased competition for resources. Across all seeding method treatments, there were no noticeable differences between yields.

Cover Crop Biomass

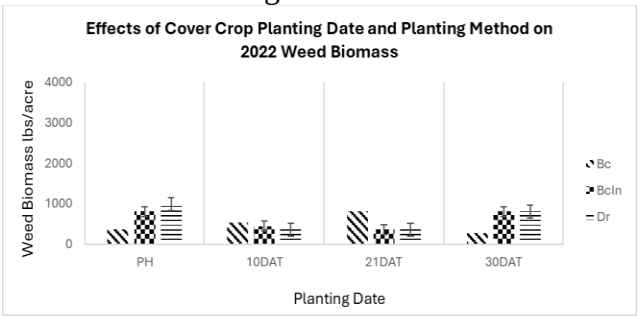
In 2022 and 2023, there was a significant impact of planting date on cover crop biomass, with the highest biomass observed at the 10 days after transplanting (10DAT). This effect observed at 10DAT is likely due to more favorable weather conditions such as warmer temperature earlier in the season, which support germination and aid growth. Additionally, planting early allows cover crops to have a longer growing period before cold temperatures set in, and to potentially access higher levels of fertility, giving them time to establish. With better establishment, early planting has been proven to improve soil coverage, which could help reduce erosion and retain soil nutrients. This suggests that planting early may support biomass accumulation overtime. No single planting method consistently outperformed the others. The steady decline in biomass over the season could be advantageous for interseeding in low-growing crops like brassicas. This gradual reduction ensures that access to sunlight remains adequate, and competition is minimized, creating an optimal environment for the growth of both the cover crop and the brassicas. This underscores the importance of timing in cover crop establishment.

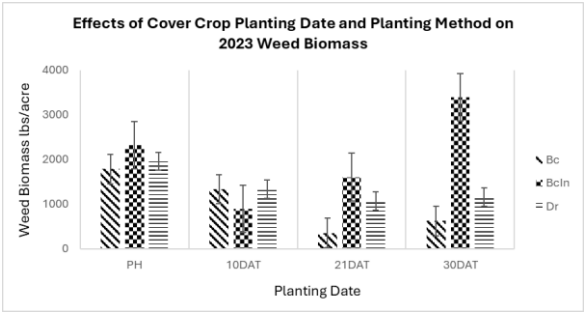




Weed Biomass

In 2022, weed biomass generally decreased at delayed cover crop planting dates, 21DAT and 30DAT, suggesting that planting cover crops late could help control weeds. A limitation with the early planting dates is that weed control operations cannot occur after the cover crop is seeded. For weeds that grow past the cover crop, this creates a longer window with no weed management options and more time for weed growth and development. Similar patterns emerged in 2023, with the control plots recording the highest weed biomass and remaining relatively high at 10DAT, then decreasing with later planting dates, 21DAT and 30DAT. The notably higher weed biomasses in 2023 could be attributed to increased rainfall, which likely provided favorable conditions for weed growth.





On-Farm Trials

On-Farm trials of this practice occurred on 4 farms. These included 2 conventional farms and 2 organically certified. On-farm logistical approaches to this practice varied widely, yet all with positive experiences. Farm A is a large operation with both herbicide and cultivator use for weed management. This farm uses wide spacing and both bare soil and plasticulture brassica production. The wide crop spacing allows for adequate sunlight reaching the cover crops and good growth. Using the cultivator to incorporate the cover crop seed at the last cultivation resulted in good germination. Some plots with a history of herbicide application had poor germination or none at all. We are still investigating what herbicide application may have been responsible for the poor germination. Farm B uses some pre-season burndown herbicide only and did not see herbicide damage to the cover crop. In year one they used a cone spin spreader to broadcast the cover crop seed. In year 2, in order to minimize the seed on the plastic, they modified a Gandy^{R} sidedress hopper to distribute seed in the wheel tracks of their cultivation tractor, meaning that the seed distribution, incorporation, and weed management was all done in one pass. Farm C preferred interseeding in their sweet corn and winter squash field. Their brassicas were planted too tightly and showed minimal benefits due to being smothered by the cabbage leaves. Farm D also planted their brassicas very tightly and saw no cover crop survival after the 2022 harvest. They are particularly concerned about overwinter erosion on their sloped fields and saw value in spacing beds more widely in 2023 and 2024 in order to have more cover crop between row survival. They both spread seed by hand or used a narrow drop spreader designed for lawn applications. All farms preferred the annual ryegrass and crimson clover mix (25 lb/A 60% ryegrass:40% clover).

CONCLUSION

In conclusion, this study emphasizes the critical role that cover crop planting dates and methods play in relationship to crop yields, the development of the cover crop biomass, and weed suppression. Our trials demonstrated the importance of the timing of final cultivation or weed management, and considerations of excessive growth of the cover crop.Our results suggest enhanced weed control and adequate cover crop biomass when cover crops were planted 21 or 30 days after transplanting. The findings also suggest that earlier planting dates, particularly at 10 days after transplanting (10DAT), are most effective for maximizing cover crop biomass. However, too much cover crop biomass can potentially affect cabbage yield through competition for resources and decrease air flow. These insights reinforce the importance of timing and planting methods in cover crop management.

Managing Brassica Insect Pests All Season Long

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Brassicas are an important crop on most vegetable farms and can be grown nearly all year long. Unfortunately, they are also under attack from a suite of insect pests all year long. Understanding pest biology can increase your chances of successfully bringing these pests under control using scouting, cultural practices, conservation biocontrol, and reduced-risk pesticides in an integrated approach relevant for conventional and organic production systems. The purpose of this presentation is to give updates on new research, new products, and to share strategies growers are using successfully to control these pests on their farms.

Winter
- Aphids in tunnels
- Cutworms

Spring
- Flea beetles (FB)
- Root maggots
- Cross-striped cabbageworm?*

Summer
- Diamondback moth
- Imported cabbageworm
- Cabbage looper
- Cross-striped cabbageworm

Fall
- Cabbage root maggot (CRM)
- Cabbage aphids (CA)
- Hawaiian beet webworm?*

<u>Important Strategies</u>
- Rotate spring from fall plantings, and fall from spring plantings—leave your worries behind! (for CRM, FB, CA—not caterpillars)
- Scout early and often in order to catch problems early, get a proper ID, and keep up with continuous pests. (FB, caterpillars, CA)
- Improve spray coverage: Hollow cone nozzles are recommended for insecticide and fungicide applications. Consider adding drop nozzles for large crops like Brussels sprouts. Always use a spreader and/or sticker to keep spray materials on foliage. (FB, caterpillars, CA)
- Continue treating as long as thresholds are exceeded—one spray will not keep all the caterpillars, or aphids, or flea beetles away.
- Till under residues as soon as possible. Mow if you cannot till in order to start the breakdown process.

<u>Other topics we will review</u>
- conventional insecticide program including new materials providing long residual control
- efficacy of OMRI-approved insecticide programs
- field-tested programs from real growers
- impacts of climate change including new pests and updated biology*

Mummy Berry: Biology and Management

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Mummy berry disease causes death of developing leaves, side branches and flowers in blueberry plants. It also produces shrunken, grey fruit called mummy berries that are seen at harvest. Both the killing and infecting of flowers directly decrease yield and death of leaves can result in smaller berries. This disease is caused by the fungus, *Monilinia vaccinii-corymbosi*, that overwinters as mummy berries (infected fruit) in the top layers of the soil or leaf litter. It produces primary spores in apothecia (cup-shaped stalked structures) in the spring, and these spores infect opening leaf and flower cluster buds. Infected flower and leaf buds continue to develop with no symptoms of infection until about seven to fourteen days later. The infected leaves first show browning of their mid-veins; the browning spreads until the whole leaf and then side branch turn brown, dies, and droops. Flowers typically die before they open and appear a brown to purplish color. Secondary spores (conidia) are produced on the dead leaf and flower tissues. The secondary spores are carried by pollinators, and other insects that visit flowers, to healthy flowers which the spores infect. The fungus grows in infected fruit as it develops and results in shriveled, grey mummy berries, as healthy fruit ripen. The mummy berries can germinate after overwintering for at least three years in soil.

Managing mummy berry disease can involve both cultural and chemical methods. Cultural methods typically decrease the number of surviving mummy berries and thereby decrease the number of primary infecting spores. Burn-pruning of lowbush blueberry fields or burning around highbush blueberry plants will destroy up to 50% of the mummy berries and decrease primary spore production. Burying the mummy berries so they cannot grow long enough stalks to reach the soil surface will also decrease initial infection. Burying the mummy berries can be accomplished in both lowbush fields and highbush plantings by putting down two inches of mulch, and in highbush plantings, by cultivating the areas around the plants to bury the mummy berries. One thing to consider is that if mummy berries produced in later seasons fall on the top of the mulch, the mulch can provide extra moisture to the mummy berries which may increase their germination.

The best time to use fungicides to decrease the effects of mummy berry disease is at the primary infection stage which will prevent the continuing of the fungal life cycle and decrease the amount of killed tissue and infected berries. Waiting to see the number of infected shoots (strikes) before deciding to apply fungicides can be tricky since shoots can die from one to two weeks after infection and infection can occur over two to three weeks. Very quickly after an infected flower or shoot dies, it produces the secondary spores that infect healthy flowers. By the time a grower has seen the dead tissues on their plants, it is likely the pollinators and other insects have already had a lot of time to transfer the secondary spores. By decreasing the amount of dead flowers and leaves, a grower can decrease the number of infected berries, maintain more healthy flowers to produce fruit, and maintain more of the leaves that are feeding the developing fruit.

The timing of mummy berry germination does not always coincide with bud break in blueberries since mummy berries have their own signals for germination. The timing of mummy berry germination and therefore apothecia production is crucial to know since it is when infective primary spores are being produced in blueberry fields. Germination can vary a great deal between years due to a particular winter and spring's temperature, precipitation, and other factors. Mummy berries have germinated in lowbush blueberry fields near Deblois, Maine from as early as April 12th to as late as May 5th and have typically continued for two to three weeks before germination ceases. In Maine, we put out mummy berry plots after harvest so that the timing of their germination can be tracked in the following spring. Typically, three mummy berry plots are placed on flat ground at least 10' apart in each monitored field. From 20 to 30 mummy berries are buried in the top ¼ to1/2 inch of soil in each plot of 4" by 4" and covered with leaf litter. The plot edges are then marked with stakes and flags. The plots are then examined from before plant bud break (early April in Maine) until mummy berry germination occurs and then for two to three weeks to track when germination ends.

When blueberry flower leaf buds are tightly closed, they are protected by bud scales that the spores cannot penetrate. The plants are susceptible to infection once the buds have opened enough to expose green, young tissues. The plant's young leaves and flowers can be infected for as long as the primary spores are being produced, and spore production has extended into early bloom in some years in lowbush blueberry fields in Maine. The spores on blueberry tissues require water to grow and infect the plant. Dew typically does not stay on the plant tissues long enough for spores to infect. Infection by spores is likely to occur after a long period of wetness on leaves from fog or rain at a suitable temperature. If the temperature is around 36 F, 10 hours of leaf wetness may be required for spores to infect, while at 46 F, only about 6 hours of wetness would be required since spores grow faster as the temperature increases.

After determining the most effective fungicide for mummy berry control available in your area and for your crop, three factors should be considered before applying fungicides. Infection may occur if primary spores are present in the field (apothecia are seen in mummy berry plots), plant buds have exposed young tissues, and there is a chance of a long period of fog or rain (typically greater than 4 to 6 hours). If dry weather is forecast, then there is very little chance of infection. For the best control of mummy berry, fungicides should be applied before an infection has occurred. There should be at least enough time before rain for the fungicide to completely dry on the plants. Growers in Maine have decreased their number of fungicide applications to control mummy berry by only applying fungicides when consistent rain or fog is forecasted. Scattered showers typically do not last long enough in one area to cause infection. This method of tracking fungal and plant development and the weather has resulted, in some years, no fungicide applications and typically one or two applications. In applying suitable fungicides this way, growers are getting good control of mummy berry with less than 5% of leaves and flowers having mummy berry symptoms. Good control of the primary infection has also resulted in fewer mummy berries produced and therefore less disease in future years.

Data-Driven Profitable Winter Greens Growing in Canada with Optional Heat

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Catherine is an agronomist and leader of the market garden team at la Ferme des Quatre-Temps. In recent years, she has become passionate (obsessed) with the idea of harvesting and selling vegetables 52 weeks per year. To achieve this, she conducted numerous tests and collected extensive data. The results of her research are presented in the book The Winter Market Gardener, which she co-authored with Jean-Martin Fortier. She will explain how she managed to make her winter production profitable and how it's possible to do even better!
Catherine will share the practices used to produce high quality greens all winter long by carefully planning succession plantings, managing insects and diseases, with an option of heat. She will share data the farm has collected on yields and profitability and provide advice on how winter growing could be profitable for your operation.

3 main strategies for winter success

To be a successful winter grower is all about how well organized you are. There is not a lot more than that, but it is a big challenge for most of us.

Three strategies will get you closer to success :

- Crop planning done at the right moment with the right planting dates
- What I call an "easy budget" that you are not scare to update weekly
- Sell vegetables before planting. Your customers might not want komatsuna, even though it grows really well in the winter!

Which crops to grow and attainable yields

When choosing which crop to grow in the winter, you should always start by what you can sell. Then, you can have fun with what is possible, and there is a lot to choose from.

You should mostly think about cold resistance, multi-harvest potential and light needs. The most unexplored and exciting potential is in Asian vegetables. Asia has a similar climate to our northern climate here in America. They grow lots of vegetables we don't know about yet. A good reference is the book "Asian Vegetables" by the Wang sisters.

Which crop you can grow is also greatly influenced by your heating strategy. i.e whether you choose to heat or not. I'll present our heating strategy at Ferme Quatre-Temps, ranging from no heat, to heating with electricity and using a new geothermal system.

Preventing problems

If you plan your winter season with the attainable yields proposed here, you need to give serious attention to the most common problems. If one of these gets into your production, you could lose everything. The point is to be aware of them, and to prevent them. Fortunately, there are simple solutions for most of them.

Problems you should worry about and how to solve them :

- Aphids and ineffective beneficial insects
- Powdery mildew and pythium
- Irrigation water that freezes
- Seed germination in suboptimal conditions

Review results

The most important part of a profitable winter season is your capacity to not only review results at the end of the season, but also every week.

An easy way to follow results week per week is to choose 3 data points you want to follow closely. For example, this year I chose to follow my heating costs every week because it is a spending account that I've had difficulty controlling in the past.

To do this week-to-week update, you'll need to use an accounting app. This is where you'll get most of your information. I always review "sold vegetables" data.

Throughout the season, there is some information you'll also want to collect: improvement in crop spacing, winter days to maturity varying with planting date and the date each crop went to seed in the spring.

Profitability calculation

I'll present my Winter 2023-2024 end of the winter season profitability calculation. We'll discuss possible improvements to reach higher profit margins.

We will see that growing vegetables in the winter is definitely possible and fun ! BUT, as for all things farming, it is hard. If you want this project to be profitable, you can not take it lightly. The profit margins can be very slim and serious attention has to be directed toward sales and spendings.

<u>Bonus</u>

To give you a head-start in your winter success, here is my planting calendar from la Ferme des Quatre-Temps. This calendar works for us in Hemmingford, QC. We are in the hardiness zone 5b. If you don't have access to a trusted fellow winter grower planting calendar, this is a good place to start and to adjust as you do some tests on your farm.

Winter Planting Dates - Ferme des Quatre-Temps

Crop	Outside, under P19 cover	Caterpillar tunnel	High tunnel	Greenhouse minimally heated
Swiss chard (Mature)	August 15	September 1	September 15	October 1
Bok choy	September 1	September 25	October 1	October 1
Carrot	August 1 No need for P19	August 10	March 15	February 15
Chinese cabbage (Tokyo Bekana)	September 1	September 25	October 5	October 15
Claytonia	August 20 No need for P19	September 10	September 15	September 20
Cilantro	September 15	September 25	October 5	October 10
Watercress	August 15	September 1	September 15	October 1
Spinach	September 1	September 15	September 15	October 1
Kale (mature)	August 15	September 1	September 15	October 1
Lettuce Salanova	August 15	September 1	September 15	October 10
Mâche	August 15 No need for P19	September 1	September 15	September 15
Baby Swiss chard	–	Mid-August	September 1	September 15
Baby kale	September 1	September 15	October 1	October 15
Mustard	September 1	September 15	October 1	October 15
Green onion	August 15	August 15	August 15 or February 15	August 15 or February 15
Sorrel	July 15	August 1	August 1	September 1
New potato	May 1	April 15	April 1	March 15
Turnip	September 1	September 15	September 15	September 20 or mid-February
Radish	September 1	September 15	September 15	September 20 or mid-February
Arugula	September 1	September 15	October 1	October 15
Asian greens	September 1	September 15	October 1	October 15
Celery	-	July 15	August 1	August 30
Parsley	July 15	August 1	August 1	August 30
Dandelion	August 1	August 15	September 1	September 15
Senposai	August 1	August 15	September 1	September 15
Komatsuna	August 1	August 15	September 1	September 15

Winter Greens Production with Unique Rotations at Trillium Hill Farm

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Farm Summary

Trillium Hill Farm is a 2-acre market garden in Hinesburg, VT, Zone 5a. 2025 will be the farm's 20th season. The farm produces mixed vegetables, with emphasis on salad crops, quick succession crops, and shoulder seasons production. The farm is Certified Organic, and Certified Real Organic.

About ¼ of the farm's produce is sold through an onsite farmstand, about ¼ through an onsite, 40-week CSA, and about ½ wholesale. The Farmstand is open April 1- Mid November. 50 or more other producers' products are purchased in to round out our own offerings. The CSA includes Spring, Summer and Fall options averaging 70 members. Wholesale sales include local grocery stores, restaurants, and a local, multi-farm cooperative CSA. Gross sales in THF produce was about $260,000 in 2023 from about 40 different crops. The farm's overall top sellers were:

Item Name	**total $**
Lettuce Mix+heads	$67,000.00
Spinach	$21,990.00
Tomatoes	$16,059.00
Kale, loose	$11,900.00
Salad Turnips	$9,134.25
Radishes (Bunch)	$8,926.00
Cucumbers	$8,669.00
Garlic	$8,310.00
Onions, fresh	$8,300.00
Beans	$8,198.00
Claytonia	$6,374.00
23 Total THF produce sales	$258,754.50

The farm includes 1/3 acre of hoop houses for in ground growing. House sizes include 2,100 sq ft, 1,500 sq ft, 1,100 sq ft. All houses are unheated, with a single layer of poly. Nearly all of the houses are planted to crops year-round.

Winter Crops

Trillium Hill Farm grows much of the standard winter greens: spinach, lettuce, kale, Asian greens/ mustards, and several less common, cold season crops, such as: Claytonia, Minutina, Cress, Sorrel, Mache and Frisee. New this year, we are trialing Italian Dandelion. The farm grows these less common crops to add diversity to sales offerings, diversity to crop rotations, and because we are not seeing opportunities for additional sales, to our current markets, in the more standard winter greens.

Winter Greens Yeilds Oct-Jan 2023

Crop	yield	Units	# beds	yield/200 sqft	More Harvests
Arugula	124	lbs	5	25	!
Asian g	75	lbs	2	38	!
Claytonia	290	lbs	5	58	!!!!
Cress	45	lbs	2	23	!!
Frisee Endive	100	bunches	1	100	!
Kale	133	lbs	1.5	89	!!
Kale	424	bunches	3.5	121	
lett Salanova	282	heads	0.75	376	
lett salanova	360	lbs	6.25	58	
Lett multi Seeded	146	lbs	5	29	!!!
Minutina	56	lbs	1	56	!!
Mizuna	40	lbs	1	40	!
Spinach	180	lbs	8	23	!!!!!!

Seeding Dates/ Harvest Periods

crop	Date	Variety	# beds	Transplant	Oct Harvest	Nov Harvest	Dec Harvest	Jan Harvest	Feb Harvest	March Harvest	April Harvest	May Harvest
arugula	9-20	astro	**1**	**Sept 26**								
Arugula	9-27	astro	2	Oct 3								
Arugula	10-4	Astro	2	Oct 10								
asian g	9-13	**tokyo bekana**	**1**	Sept 19								
Asian g	9-13	**yukina Savoy**	**1**	**Sept 19**								
claytonia	**8-30**		**1**	TP sept 15								
claytonia	**9-6**		**4**	sept 22								
cress	**9-6**		**2**	**sept 19**								
Frisee Endive	8-23	**Benefine**	**1**	tp sept 5th						?		
Frisee Endive	9-13	**Benefine**	**1**	Sept 22								
kale	8-9	darkibor	3	TP A18								
kale	**8-16**	**darkibor**	**2**	**TP A20**								
lett	**8-23**	**Salanova**	**2**	Sept 13								
lett	**8-30**	**salanova**	**2**	**TP sept 22**								
Lett	**9-6**	**salanova**	**4**	**sept 29**								
Lett baby	9-20	**various**	**2**	TP Sept 26								
Lett baby	9-13	**various**	**2**	**Sept 19**								
Lett baby	10-18	**various**	**2**	Dec 1								
Lett baby	10-25	**various**	**2**	Dec 1								
Minutina	**9-6**		**1**	**sept 19**								
mizuna	9-20		1 bed	Sept 26								
Onion	**8-30**	**bridger, Hi keeper, Red Spring**	**4**	**11000 seeds TP sept 22**								
sorrel	9-20		2	Oct 20								
Spinach	**8-30**	**various**	**3**	**TP sept 15**								
Spinach	**9-6**	**various**	**2**	**TP sept 15**								
Spinach	9-13	**various**	**4**	**Sept 22**								
spinach	9-20	**various**	2	filling gaps								
turnip	**9-6**	hakurei	1	tp S12								

Rotations

The farm has 2 garden sites with a hoophouse rotation for each. Most of the rotation placement is based on timing. For the purpose of this presentation, I'm only listing the crops that are in these hoophouses going into the winter, but they are also filled with summer crops too. The crops rotate in descending order.

Lower Garden:

1. Claytonia, Minutina, and Frisee
2. Kale, Turnips, carrots
3. Spinach
4. Lettuce

Upper Garden:

1. Cress and Sorrel
2. Lettuce and Onions
3. Carrot
4. Arugula
5. Fall cover Crop/ Spring Spinach
6. Asian Greens

Winter Spinach Production & Pests

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Winter high tunnel production systems. There is a wide variety of winter spinach production systems in the Northeast, ranging from low-input, manual systems to highly mechanized, specialized systems. In southern New England, spinach is seeded by early October to achieve the best yields. The recommended seeding rate, based on high-density plantings in the spinach-producing regions of California and Arizona, is 70 seeds/ft^2. Many growers seed with a walk-behind seeder; tractor-mounted seeders also exist for larger-scale farms. Some growers transplant spinach into tunnels to maximize the time summer crops can remain in the tunnels while still achieving spinach harvests by Thanksgiving time.

Harvesting techniques also vary across farms, with some farms harvesting leaf-by-leaf either by hand or with knives, or by clear-cutting just above the growing point. Some mid-size growers use drill-powered greens harvesters, and large-scale growers may use tractor-mounted harvesters.

If spinach is to be washed before being marketed, growers need a warm place to wash and pack. Depending on the market, spinach does not necessarily need to be washed and may have a longer shelf life if it remains unwashed. If spinach is washed, it must be thoroughly and gently dried before going to market—hand-cranked greens spinners are commonly used, and washing machines can be converted into spinners for larger-scale growers. The University of Vermont Agricultural Engineering Program has Washing Machine/Greens Spinner Conversion Guide available at https://blog.uvm.edu/cwcallah/2022/02/24/washing-machine-greens-spinner-conversion-guide/.

Case studies. Over the winter of 2020-2021 the UMass Extension Vegetable Program conducted case studies of three spinach production systems to evaluate a range of scales and methods.

Farm 1 was the smallest-scale and most manual of the three farms and marketed their spinach solely through a winter CSA spinach add-on. They prepped the tunnel with a rototiller with a BCS attachment, then formed beds with hand tools. Spinach was seeded with a walk-behind Jang seeder, and harvested leaf-by-leaf, by hand. All of the labor was done by the farm owner. Farm 1 had very low input and equipment costs but also a very low price per lb and therefore had the lowest profitability of the three farms.

Farm 2 was a mid-sized farm but only grew a small amount of spinach, in a tunnel with a winter lettuce crop. The spinach was marketed via wholesale and retail. This farm transplanted spinach in order to keep their summer tomato in the ground as late as possible but still achieve Thanksgiving spinach harvests. Tunnels were prepped using tractor-mounted cultivation equipment. Spinach transplants were seeded in early September and transplanted into the tunnel in early October. Transplanting the spinach resulted in a significantly lower density planting than the other case study farms and our recommended rate. This farm

covered their spinach crop with row cover. Spinach was harvested by cutting the lower leaves by knife, leaving the smaller leaves uncut. Downy mildew developed on the spinach on this farm, but the farmer felt that the time spent harvesting leaf-by-leaf allowed them to keep the relatively fewer plants healthy and producing longer. This farm had high labor and materials costs, due to transplant production and harvest method, but ended up having the highest profitability due to their high price per lb and due to crop losses experienced by Farm 3.

Farm 3 was the most specialized and mechanized of the case study farms, only growing winter greens. Spinach was sold solely through wholesale accounts. Tunnel prep, seeding, and harvesting were all done using tractor-mounted equipment, resulting in high equipment costs but very low labor costs. Spinach was seeded through mid-October. This farm would have been the most profitable of the three farms had they met their yield expectations, however they experienced significant crop loss due to Cladosporium leaf spot in our case study year, exemplifying both the potential benefits and risks of specialization.

Table 1. Winter spinach case study.

	Farm 1	**Farm 2**	**Farm 3**
Tunnel size	1,350 ft^2	3,000 ft^2	6,000 ft^2
Equipment cost*	$0	$55,350	$75,140
Plant density	80 plants/ft^2	2.5 plants/ft^2	140 plants/ft^2
Labor time	0.07 hrs/ft^2	0.02 hrs/ft^2	0.003 hrs/ft^2
Labor cost	$1.29/$ft^2$	$0.42/$ft^2$	0.05/ft^2
Production materials cost	$0.05/$ft^2$	$0.77/$ft^2$	0.08/ft^2
Average price/lb	$6.41	$10.25	$9.75
Yield from tunnel	0.34 lbs/ft^2	0.27 lbs/ft^2	0.19 lbs/ft^2
Sales from tunnel	$2.22/$ft^2$	$2.75/$ft^2$	$1.53/$ft^2$
Profit per ft^2**	$0.88	$1.56	$1.40

*Equipment was used across the farm on multiple crops.
**Does not include production materials post-harvest equipment, labor, or materials.

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No-Till Winter Production Using Innovative Relay Cropping Techniques

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Stonecipher Farm aims to offer quality produce for their markets year-round. The benefits of year-round production include retaining employees and customers throughout the whole year. Tunnels play a large role in Stonecipher Farm's ability to do this: more tunnels = more assurance. A farm can never have too many tunnels and with NRCS funding, farms should utilize these tools for their multiple benefits, including climate change resilience. Larger tunnels are preferable, since they are more user-friendly and have better climate control due to their larger air mass. We use double poly tunnels and pay close attention to tunnel orientation during site selection and construction with snow load in mind; we do not clear snow off our tunnels in the winter.

At Stonecipher Farm, our tunnels have permanent water hookups through four-season hydrants and we have three-season alternate water sources. We prioritize automation at our farm—automation is our best employee! Each tunnel as 100 amp service to power our technology, including thermostatic controls, louvres, fans, and roll up sides for climate control. Air movement is critical in our tunnels to prevent cold damage. We also use overhead water for frost protection, in addition to hoops and row cover. Irrigation and nitrogen fertility in the winter are critical for crop yields.

No-till management and use of beneficial insects have allowed us to reduce our pest pressure on the farm. We have experienced reduced weed pressure using no-till systems. Beds are situated sideways for airflow to reduce disease. We use habitat plantings to draw in parasitoid wasps, pollinators, and natural enemies for aphid control and crop pollination. We also buy in beneficial insects and mites for pest management. Foliar sprays and inoculations using compost tea, seaweed, and fish emulsion, and improving ecological diversity on the farm allows us to grow healthy plants that are high yielding and better able to tolerate pests and disease.

Relay cropping is another practice that we attribute to our success in growing year-round at Stonecipher Farm. With clever timing of plantings, we can maximize production on a small scale. For example, we sow lettuce mix between scallion rows, and then cut the greens in February as the scallions start to take off. All beds in all tunnels are under full production as we relay another crop in. We try to think "beyond kale," growing diverse crops with diverse harvest windows. With many more farmers doing winter production, there are certain crops that have reached saturation at markets. We try to think creatively about varieties, dates and scheduling, bending and breaking all the rules in the "off season" to gain an advantage with our markets. We direct seed crops into the tunnels every month of the year, taking advantage of transitioning crops & shoulder seasons. Tarps are another tool we utilize at Stonecipher to accelerate germination.

The New AI: Transforming Farm Marketing with Artificial Intelligence

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This document reflects knowledge and examples accurate as of November 2024. Generative AI technologies are advancing quickly, so readers are encouraged to consult up-to-date resources for the latest capabilities, limitations, and best practices.

Challenges in Farm Marketing for Direct-to-Consumer Farms

Marketing is one of the most time-intensive tasks on direct-to-consumer farms. Maintaining an active online presence requires a significant investment in communication via social media, newsletters, websites, and email. For many farms, adoption of digital marketing practices is hindered by limited technical skills, high time commitments, and resource constraints. [1] Time spent connecting with customers online often pays off however as research shows that using digital tools can lead to substantial improvements in both operational efficiency and market presence.[2]

So how can New England farmers balance the need to be grower, milker, mechanic, accountant, salesperson and marketing specialist all in one day? Generative AI tools offer a practical way to bridge this gap, by creating customized, relevant content with minimal effort and helping to bring efficiency to routine customer communication.

What is Generative AI?

Generative AI is a form of artificial intelligence that creates new content—such as text, images, or other data—based on patterns learned from extensive datasets. This technology has seen significant advancements in recent years, making it increasingly accessible and applicable to diverse industries, including agriculture.

A Focus on ChatGPT:

ChatGPT, developed by OpenAI, is a text-based generative AI tool capable of generating human-like responses, assisting with creative tasks, answering questions, and drafting content. ChatGPT is built on advanced technology that processes large amounts of data to learn how words and sentences connect to create meaning. When you type in a question or prompt, ChatGPT analyzes it and generates a response that's relevant and sounds conversational.

For farmers, this means ChatGPT can assist with tasks like writing social media posts, answering frequently asked questions, and brainstorming ideas for newsletters or marketing materials. This can be especially helpful for direct-to-consumer operations, where farmers have the most to gain from increasing the efficiency of tasks like content creation and customer engagement.

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[1] Pesci, S., Galt, R. E., Durant, J. L., Manser, G. M., Asprooth, L., & Pinzón, N. (2023). A digital divide in direct market farmers' online sales and marketing: Early pandemic evidence from California. *Journal of Rural Studies, 101*, 103038. https://doi.org/10.1016/j.jrurstud.2023.103038

[2] Rahmadani, E., & Elinur, E. (2024). Digital Marketing Strategies in Increasing the Competitiveness of Agricultural Products in the Digital Economy Era. Global International Journal of Innovative Research, 2(9).

Use Cases and Practical Examples:

1. **Content Creation for Social Media and Newsletters:**
   Example: A blueberry farm can use ChatGPT to generate social media posts inviting visitors to a seasonal berry-picking event. The farmer enters a detailed prompt like, "Write a friendly Facebook post inviting families to our blueberry-picking event this Saturday in the White Mountains, including details on time, pricing, family-friendly activities, and tips for the best picking." ChatGPT would generate a compelling post that conveys event details in a warm tone, significantly reducing time spent drafting content.

2. **Automated Customer Engagement:**
   Example: When a farmer is updating their website, ChatGPT can help create an FAQ page to address common customer questions, such as "What produce is in season?" or "How should I store fresh tomatoes?" By using a prompt like, "I run a small vegetable farm in New Hampshire and am building a new website. Can you help write an FAQ page for potential CSA customers, answering questions like, 'What produce is available each season?' 'How should I store fresh tomatoes?' and 'What are the CSA membership options and costs?' Please make the responses friendly and informative." ChatGPT generates a response according to the need and tone outline in the detailed prompt, providing a first draft of the FAQ page that will enhance the website's user experience, improve SEO, and save the farmer time by reducing the need for one-on-one customer interactions.

3. **Automating Market Day Announcements from a Pick Sheet:**
   Example: A farmer preparing for a weekend farmers' market can use ChatGPT to turn a list of available produce from their pick sheet into a social media update. By entering a prompt like, "List all the items on this pick sheet and create a lively Instagram post announcing what customers can find at our farmers' market booth this Saturday," ChatGPT can quickly transform the list into a polished, engaging post. Users can even attach a photo of the pick sheet and have ChatGPT pull out the text of the items on the list as a first step!

Important Note on Generative AI Limitations:
While ChatGPT can produce helpful content and ideas, it can and does generate information that needs to be fact-checked! All ChatGPT users should review and refine AI-generated content to ensure accuracy and appropriateness for their specific audience.

Getting Started

Accessing ChatGPT:
Farmers can access ChatGPT via OpenAI's platform (https://chat.openai.com/). The subscription options currently available as of November 2024 are:

- **Free Tier:** Access to ChatGPT using GPT-3.5 with basic capabilities, though availability may be limited during peak times.
- **ChatGPT Plus:** $20/month for priority access to GPT-4, providing more accurate responses and faster processing speeds. Ideal for users needing reliable access and advanced capabilities.

Prompting Basics:

- **ChatGPT vs. Google Search:** Prompting in ChatGPT requires a different approach from traditional keyword-based search engines like Google. Google is optimized for specific keyword searches to find external information, so the fewest number of words is often best. ChatGPT relies on well-phrased prompts to generate new content or respond contextually based on its training. Instead of asking ChatGPT for a direct answer like a search engine, it's often more effective to *ask* ChatGPT to simulate a task or write content with specific details. For example, "Write a post inviting families to our pumpkin-picking event…" will yield a more relevant response than "pumpkin-picking event information."

Data Privacy, Ownership, and Security FAQs

Who Owns ChatGPT-Generated Content?

According to OpenAI's terms of service (https://openai.com/policies/row-terms-of-use/), users retain ownership of the content generated by ChatGPT. This means that farmers can use ChatGPT's output freely, including for commercial purposes, as long as it doesn't include copyrighted material or sensitive data that might restrict its use. For farm-related marketing content, this allows users to publish, distribute, or monetize the generated text without requiring additional permissions from OpenAI.

What Happens to Data Entered into ChatGPT?

OpenAI's standard policies may retain input data temporarily to improve model performance, unless a business user has disabled data retention in settings. Users can enable "Incognito Mode" to prevent OpenAI from retaining input for training. For sensitive data, such as proprietary spreadsheet contents, OpenAI advises against inputting identifiable or confidential information.

Conclusion

Generative AI, such as ChatGPT, offers New England farmers a powerful tool for streamlining marketing tasks, creating engaging content, and maintaining customer relationships. By managing routine and repetitive tasks like content creation, ChatGPT can help reduce the time required for direct-to-consumer marketing, allowing farmers to focus more on production and operations—or perhaps even on non-farming activities and hobbies!

As always, remember that this information is general guidance to help you understand the basics, but it should not be considered a substitute for professional legal advice.

What Do New Englanders Prioritize When Purchasing Food?

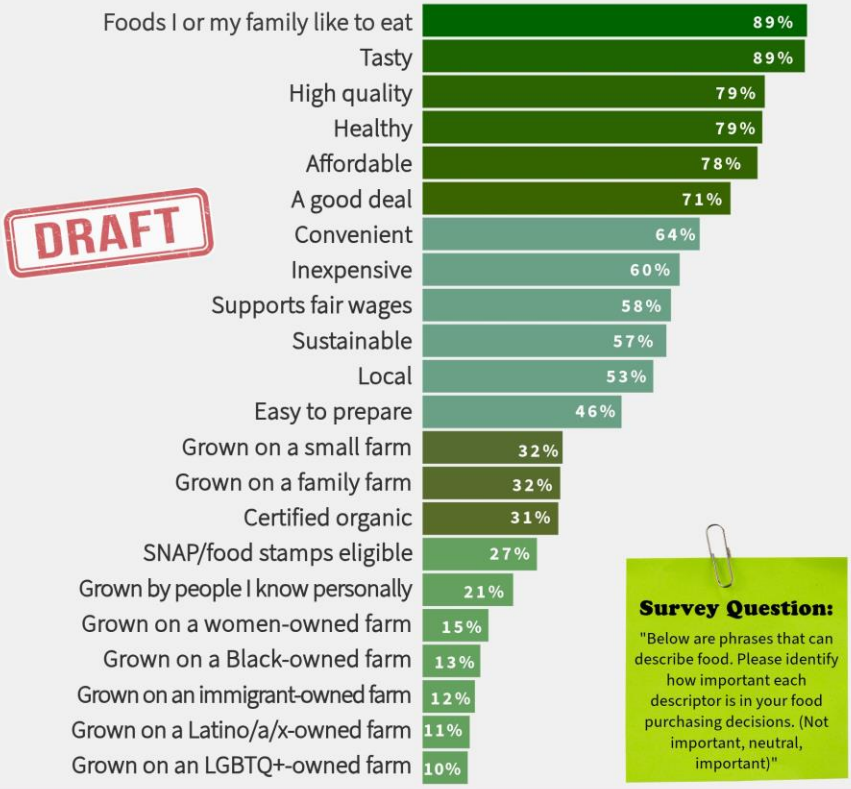
UNH Food Systems Lab

Cindy Zheng, Olivia Burton, Hannah Stokes-Ramos, Jess Carson*, Isaac Leslie, Analena Bruce*

Study Purpose & Approach

We conducted a population-based survey of food shopping habits and preferences to inform decision-making about ways to expand market access for New England's food producers. Our findings can be generalized to the adult population of New England.

Percentage of New England Adults Selecting Each Attribute as "Important" in their Food Purchasing Decisions



Survey Question:

"Below are phrases that can describe food. Please identify how important each descriptor is in your food purchasing decisions. (Not important, neutral, important)"

Key Insights

- Over 70% say taste, preference, health, & quality are important

Food producers could emphasize taste, health, & quality to appeal to a majority of New Englanders

- About half say local, sustainable and fair wages are important

The importance of local, sustainable food, & fair wages needs to be communicated

- How food is grown is important to fewer

The importance of organic certification & small farms needs communicating

- Knowing the grower is important to a fifth

The importance of producer & consumer relationships needs revisiting

Key Takeaway

Half of New Englanders say local food is important to them, but food grown on small farms is not. This disconnect calls for education on the importance of small farms for local food and sustainability in the region.

University of New Hampshire, "New England Food Shopping Habits and Preferences Survey," collected 11/2022 -3/2023 by UNH Survey Center. Note: Estimates are weighted. Number of valid responses varies by item; to maximize use of our sample, we retained all respondents with a valid response in its corresponding estimate. Valid responses vary from N = 2,062 to "Grown on a Black-owned farm" to N = 2,084 for "Inexpensive". Funded by USDA NIFA, AFRI Grant #110394; views expressed here do not represent the funder.

*Jess Carson led survey, Analena Bruce is Project Director. Email Analena.Bruce@unh.edu or see website for more information. https://www.unhfoodsystemslab.net/

Building Your Retail Space: Strategies for a Cohesive Customer Experience

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MX Morningstar is an agricultural & retail business located in the upper Hudson Valley. The farm grows diversified produce for its farm store and CSA as well as managing large scale acreage of crops for sale primarily to farms and distributors. The store sells its own farm-grown produce, local and imported fruits and vegetables, dry goods, meat, fish, bread, and a myriad of specialty ingredients for the modern kitchen.

The store was born out of many years of a successful farmers' markets presence; in part due to beautiful displays, excellent quality standards and attentive customer service. The farm's move to a new location in 2019 gave us the possibility to open up to the public and that, coupled with the community's need during COVID, created the store as we now know it.

Much of our early success can be attributed to the influx of residents due to COVID; Hudson had one of the largest numbers of new residents in the country between 2020 and 2021. Because many customers sought out smaller spaces to shop they found our store to be a good fit for their needs. But new customers require work and effort to keep! Much of our growth, and customer retention, can be attributed to the decisions we made in the following areas:

Identity
To Banana or not to Banana?

What do you want to put in and get out of your retail operation? What are you known for and how does this overlap the demographic spread of your community? There are many questions to consider when planning a retail space: seasonality, schedule, labor input, product selection, audience, etc… Pinpoint what you do best, and consider how you want your retail operation to compliment that.

Routine vs. Destination: Find your main identity between the trifecta of farm retail establishments: PYO & agritourism, seasonal farm stand, and year round store. This is not the end-all and be-all but is just a good rule of thumb when figuring out who you are interacting with and how you want to interact with them. This should make sense for the area that you are in and the population you are serving. Don't be scared to pivot and don't be scared to change as your demographic changes!

Reliability + Hours: Routine store or seasonal farm stand? Hours and days open should be conducive to the targeted audience (i.e. 7 days per week for a routine stop vs. 4 days per week for a seasonal destination)

Merchandising: You don't need to do it all. Stores and businesses with a clearly presented identity lend to a comfortable and enjoyable shopping experience.

- Start with staples that best compliment your farm output and expand piece by piece. It takes time to learn your audience. Build consistency in your product offerings.
- Choose products that you can stand behind.
- Ask yourself, is this a banana? *(more on the "banana" at our talk!)*

Interior & Space:
Customers are {beautiful & independent} Cows

Design your store layout in a way that is conducive to spending time shopping by creating a merchandising flow. What do you want to convey when potential customers first walk through your doors? Fresh is best! Putting something beautiful up front, such as flowers or fresh fruit, conveys a bright, refreshing environment. Place desirable grocery staples, such as milk or eggs, towards the back of the store to draw the customer through and give them the opportunity to peruse other products. The more time a customer spends in your store, the more likely it is that they will pick something up. We are creatures of comfort! The more comfortable, warm, and inviting your space is, the more time someone will want to spend there. It should feel easy to move through your store and find products in a sensible order.

Layout and flow: Utilize existing retail theories and apply them to your space and desired outcome.

- The theory of invariant right (aka, most people will turn right then walk counterclockwise towards the checkout area.) Design your departments and aisles by creating a counterclockwise traffic pattern leading back towards the checkout. Work within your space. It doesn't have to be perfect but it could definitely feel "wrong" if there isn't some thought put into the customer shopping & checkout flow.
- The entryway is called the "decompression zone": not good for sales but good for setting ambiance. If you have space, put something here that will set the tone for your desired shopping experience. This is a good spot to put something that will slow people down on entry; some sort of physical barrier that will aid with the mental reset required when entering a new space. E.g. We use our shopping baskets as a physical and mental stop for customers.
- Checkout location: Typically a register would be on the left side of a store, opposite from the entrance, and about 15-20 ft from the exit. Take into account customer traffic and consider where lines will form when multiple customers are ready to checkout. You want to avoid having checkout lines disrupting shopping flow as well as crossing into customers entering the building.

Merchandising: Make it make sense!

- Product spread:
    - Think of your space and product. Consider what staples would best compliment your farm output and work within typical categories to create your "sets."
    - Don't put a ring on it just because you like it. I.e. don't carry something just because *you* like it if it doesn't fit the merchandising parameters of the store.
- Quality control: Embrace the waste! It takes time to establish yourself consistently in a customer's routine. For this reason, it may be necessary to waste more product in the beginning in order to create a baseline of quality for the customer.

- Pricing: Your pricing needs to be congruent. Are you on the higher end? The lower end? Do you have space for three pricing tiers? If you do not have space for two to three pricing tiers (low-mid-high) then pick a general price point and stick to it. Customers are attracted to reliability and reliability on price is very important. Your service must, at a minimum, match your pricing.
- Pricing denotes quality. Make sure your quality corresponds to your price.

The "Exterior" and The Exterior
It's the outside that counts.

How do you present your business? It is important to create and maintain continuity between all the aspects of your public facing identity. Who you are and what you are doing should be easily decipherable by a customer, either consciously or unconsciously, through the tools you use to present your public face. This can include things like social media and print media, the choice of produce bags and shopping baskets you provide for customers, your quality control standards, and, among many other things, the customer experience you create.

Marketing: *Everything* you do is marketing! Marketing is the act of creating and maintaining customer relationships. Your staff is marketing. Your branding is marketing. Your product selection is marketing. Your store displays are marketing. Your entire outward projection is marketing. Don't panic! Some tips are:
- Make sure your branding is consistent with your mission and store ambiance.
    - A refresher: branding is establishing your business's identity, marketing is the process of promoting your business and engaging with your customers.
- Create the ambiance that feels comfortable for you to maintain and train your staff into it.
- Find your flow within your time and capabilities, both financial and skillswise. You don't have to do it all.

Location, location, location: Your geographic location influences your customer base. Be observant of who you might be selling to/are currently selling to and attracting; use data!
- Take into account the income bracket of your area when deciding what type of store you would like to create. For example, our store is located in a rural area with a strong summer tourism market and for this reason it makes the most sense for us to offer two price points wherever possible. High-end specialty products do well with our visiting tourists, while more affordable staples are better attuned to the local community. Offering both allows us to capture a broader customer base which in turn creates more consistent and reliable foot traffic throughout the year.
- Run a traffic survey: how many cars pass in front of your store every day? And when?
    - Contact your local DOT branch to hire a survey crew or, depending on your state, you will be able to find some information online. In NYS you can find some traffic data at: https://www.dot.ny.gov/tdv
    - You can also use traffic data to track peak travel hours. Combine this with your POS reporting and your general observations to create optimal open and close times for your customer base.

Exterior: Lights, Signage, & Parking. You don't need perfection, just safety.

- Exterior lights will attract more customers during the fall & winter hours. They create ambiance and a safe feeling for both staff and customers alike.
- Entry/Exit & Other signage: assume everyone is unsure of pulling into a place they haven't been before. Be inviting. Make sure your store's entry door is clear to your customers and that your hours of operation are stated in more than one place. Use open flags, letterboard signs, and a-frames as quick solutions to convey information.
- Parking Lines: If you do not already, you will have a photos folder titled "Spatial Reasoning Has Left The Chat", truly the kindest way to put it, full of absolutely mind boggling parking jobs. Maybe one day you might look at it with fondness, but do not trust to hope. So let's save you that google storage subscription; make it your #1 exterior mission to have parking lines in any way, shape or form. You cannot have enough parking cues so don't worry about going overboard as the board doesn't exist here.

Staffing & Knowledge: Your staff are the face of your business and they will be the primary party responsible for the upkeep of your vision. Spend time establishing your desired store identity and how you want it presented, and give your staff the time and tools they need to represent you well and take good care of your patrons.

- Training: Train your staff well and consistently. Create protocols, procedures, and policies to arm your staff with the tools necessary to maintain a consistent customer experience.
- Customer service mission: Anyone can open a store with the same products as you. How you present your store and take care of your customers will be the difference between you and your competitors.

Marketing Your Farm Through Authentic Storytelling

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There's a saying that goes, "facts tell, stories sell." When it comes to effective marketing, you need to have both — your prospective customers do need the facts of what you sell and how they can purchase your products. But it's the stories you share that differentiate your farm, build trust, and cultivate connection with your customers.

In this workshop, we'll dig into how to use storytelling to build long-term customer relationships.

You'll learn how to identify compelling stories, how to adapt stories to different lengths and platforms (including your website, social media, and email marketing), and how to use storytelling in sales. Stories can come from anywhere: the field, the greenhouse, the kitchen, your childhood. Stories don't have to be long or perfectly written. Think of them like seeds. A single sentence can be enough to spark a potential customer's curiosity, or to help a current customer feel a deeper connection with you and the food they're buying. The key is to connect the story you tell with the product you're selling and the person you're selling it to. To do this, we'll focus on three things: who you are, who your ideal customer is, and developing your core stories.

Who You Are

Starting with who you are and your vision for your farm will guide the types of stories you share and help customers connect with the "why" behind what you do. One way to do this is to develop a Holistic Goal. This is made up of three parts: quality of life statements, behaviors and systems, and vision. The first two parts help develop the vision. The vision will become the foundation from which your stories sprout. Rooting stories in your farm vision will help create a values-based connection with customers.

To learn more about developing a Holistic Goal, visit: katiespring.com/create-holistic-goal-farm-life

Your Ideal Customer

Knowing who your ideal customer is shapes how you speak, write, and market to them. The power of knowing your ideal customer is that you can stop guessing who you're trying to reach and focus on one person. You don't have to try to convince everyone to buy from you — instead, you can grow the relationship with your ideal customer: someone who shares your values and is looking for what you have.

While the goal is to sell to many customers, creating one specific person as your ideal customer will actually allow you to reach more people. There's a saying that goes, "when you're talking to everybody, you're talking to nobody." Trying to reach everyone will actually dilute your

message. On the flip side, speaking directly to one person will draw many more in to learn about your offer.

Use the questions below as a starting point. If you already have an ideal customer in real life, you can think of them. If you don't, make someone up — there are over 7 billion people in the world, so it's very likely that even a made up ideal customer actually exists.

The goal here is to understand your ideal customers in a way that allows you to genuinely connect with them and speak to them in a way that makes them feel seen, heard, understood, and excited to buy from you. Remember, what you're offering is valuable and important, not just on an individual level but on a community, regional, even global level. Authentic marketing will help you grow your positive impact and enrich the lives of your customers along the way.
Ideal Customer Questions:

- Name & age:
- Family (kids, spouse, if any):
- Worldview (what do they believe in and care about):
- What do they do for work:
- How much money do they make:
- What they do for fun:
- What specific media do they read/watch/listen to (magazines, blogs, podcasts, tv, etc):
- What's one thing they look forward to every week?
    - *For example, do they go to the local bakery for croissants or stroll through the farmers market every Saturday? This prompt is meant to get you thinking of what currently brings joy to their daily lives.*
- What do they dream about:
    - *For example, are they foodies who dream about a food & biking tour of Italy? This prompt is meant to get you thinking of what makes them smile and what they want more of in their lives.*
- What are their frustrations:
    - *This can be in relation to your offerings or not. For example, your IFC might say: "My grandma always made the best meals from her garden, but I can barely cook spaghetti. Anyway, none of the tomatoes from Shaw's taste like the ones my grandma grew. I wish my kids could experience how joyful family dinners were when I was growing up."*
- What is their ideal solution to those fears and frustrations:
    - *In response to the example above, your IFC might say: "I wish there was a place I could get tomatoes that tasted as good as they used to. Maybe my kids would actually stay sitting at the dinner table if they liked what I made."*
- What does their ideal life look like, in relation to what you're selling:
    - *Based on the above two prompts, consider how your farm offering can address or help alleviate these fears or frustrations. For example, how does local food differ from the supermarket options, and how can eating local food bring more joy to their family table?*

Your Offer & Stories
Stories don't have to be long. Here's an example of using stories in your sales:

Example 1:

"We grow brandywine tomatoes because they taste great. Want to try one? They're $5/lb."

Example 2:

"My grandma used to slice tomatoes, sprinkle them with salt, and dish them out to me and my cousins on summer afternoons. I still think of her every time I bite into a ripe brandywine. Want to try one? They're $5/lb."

Stories let your customers feel the why behind your product and create a tangible connection between your offering and their desires. In both scenarios, you're not tricking anyone into buying a tomato. But in the second one you are offering an honest glimpse into why you grow tomatoes, and that story creates an opening for a customer to connect with you and decide to buy.

Stories are all around us, but sometimes we need a few prompts to find them. Use the questions below as a starting point to find your farm's foundational stories.
Farm Story Questions:

- *What's your earliest food memory?*
- *Why did you start farming?*
- *Why do you keep farming?*
- *What's your favorite thing about farming?*
- *What's your favorite meal to cook from your farm's produce and/or livestock?*
- *What's your favorite crop to grow and why?*
- *If you were a vegetable, what would you be and why? (this is a fun one that's great for in-person conversations)*

As you tell stories, consider how what you're offering overlaps with what your customers value, what they're looking for, and where and how they get their information. Practice telling stories in different lengths, from one to three sentences in a social media caption, to a few paragraphs in an email or on your website. Take note of what types of stories come up naturally in conversations with customers. Questions from customers are often a great place to find what stories are valuable to them.

For more on storytelling and farm marketing, visit katiespring.com/resources

J1 Student Visa Highlights

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Gove Farm has been hosting J1 interns for over 25 years. We have hosted 90 students from over 20 countries. We currently work with 2 programs based in Minnesota, MAST and CAEP. Ideally we have 3 or 4 trainees. We provide housing but they live on their own.

A few things we have learned over the years:

- If you are looking for someone just to work this program may not be for you. Working is an important part of the program. However, the trainees are interested I learning about the U.S., the culture, the language and new experiences. As a host you should encourage them to branch out.
- Most of the interns are in their mid-twenties but we've had students as young as 19 and as old as 31.
- We like to have our interns from a variety of countries so that English is the common language. Many of our interns are going on to do a semester at the University of Minnesota and a command of English makes the transition much easier.
- Most of the interns have studied agriculture. Not all are from a farming background so may not have practical farming experience. They are interested in learning new farming techniques and can offer ideas some useful points of view.
- There can be tremendous cultural differences between the host family and the other students. One of the most significant problems we've experienced is that not everyone will take instructions from a woman.
- Many times it's the first time the students have lived on their own. It's important to establish house rules early.
- A training plan with details learning and work expectations is vital.
- Unlike the H2A visa, J1 does not require inspections. There are often annual visits from the program coordinator.
- Culturally we often learn as much as the trainees.
- J1 only allows the students to stay one year. So every year you have to train a new group of employees.
- We do often get students recommended by past trainees.
- As with all programs, we have spectacular trainees and difficult ones. Many we are still in touch with.

Hosting international Students through the J1 Visa Program Panel

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My farm has been hosting J1 Visa Students since 2007. We came along the program through a neighboring farmer and have never looked back. Each year, we host 2-4 students from across the globe though the J1 Visa Program called 'Communicating for Agriculture Exchange Program'. This program has allowed us to employ students who are deeply passionate about agriculture in their countries and are looking to expand their horizons learning about agriculture in the United States.

The purpose of this speaking program is to help others understand working with the J1 visa program and process. I will talk about how to obtain interns from the program and how to welcome them to your farm. My farm also hosts H2A Visa workers as well, so I will be discussing managing both the J1 and H2A Visas. I will also touch on my personal experience with these workers both on the farm and in everyday life. The workers through this program have become family to me and I keep in touch with all of them to this day.

I am hoping through this talk that I can shed a light on this program and explain the benefits that it can have on your farm.

Understanding Burnout: Strategies for Prevention and Management

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Everyone has mental health, and no one is immune to burnout. The objectives of this session are to help participants understand burnout on the mental health continuum which illustrates a range of concerns. The range covers a situation where an individual is flourishing to an individual who is severely impacted by everyday activities. This session will further strive to help participants understand cumulative stress and burnout, understand causes and identify strategies to address and/or manage them, and understand ways to help to manage mental wellbeing.

According to a 2022 study (Branagh R. O'Shaughnessy et al), across North American, European and Australian studies, the average prevalence of severe burnout in farmers was 13.72%. Compared to non-farmers, farmers experienced higher overall burnout, and higher exhaustion, cynicism and professional efficacy. Gender differences indicated that women experience higher burnout than males.

It is important to understand that burnout is not depression, and it isn't a simple result of long hours. Burnout manifests with signs of no longer caring, no longer having energy, and no longer feeling like efforts matter. It is sustained exhaustion and deflation. Burnout impacts not only levels of stress and low job satisfaction, but it also spills over into other areas of life and could cause marital problems and family conflicts. It can create physical symptoms such as fatigue, insomnia, substance abuse, a weakened immune system, heart disease, and increased risk of suicide. There are several signs of burnout included in three broad categories of physical and emotional exhaustion, cynicism and feelings of ineffectiveness. A work environment can also influence burnout. We will discuss the many signs of burnout and examples of work environment burnout during the presentation.

The session will include examples of tools for participants to take home to help family and friends who are experiencing physical or mental exhaustion, detachment or low self-esteem. To lighten the topic, while addressing the seriousness too, this presentation includes a short video which includes humor. The video is part of the Confident Conversation curriculum which also includes a curriculum guide, lesson plans, and handouts. For more information about the Confident Conversation curriculum, contact Maria Pippidis

The North East Farm and Ranch Stress Assistance Network also known as Cultivemos, provided funding for this project.

Navigating Agricultural Overtime Laws in New England

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The Fair Labor Standards Act (FLSA) does not require employees employed in "agriculture"[3] to receive the federal overtime payment of time and a half of their regular rates for hours worked more than 40 hours per week if any exemptions discussed below apply. In addition, individual states can enact their own laws regulating mandatory overtime requirements for agricultural workers. Given that federal and state laws intersect, when and which employees qualify for overtime pay can be difficult to discern. The materials below and our presentation aim to demystify the unique regulatory structure and provide you with the tools to reach the determination of whether and when you or your workers qualify for overtime pay.

We also invite you to submit questions regarding agricultural overtime laws in advance of our presentation, by email (addresses above), which we will do our best to answer in the time allotted for the presentation.

Federal Exemptions to Overtime under FLSA

FLSA Section 213(a)(6) states that overtime does not apply to: certain small farms (no more than 500 man-days in any calendar quarter in the preceding year); immediate family members of farmers; certain seasonal hand-harvest workers paid on a piece-rate basis (see statute[4] for specific requirements); children under 16 who work on the same farm as their parent and are employed as hand-harvest workers paid on a piece-rate basis; and employees engaged in the "range production of livestock" so long as the employees are "employed in agriculture."

The phrase "employed in agriculture" has been interpreted by the U.S. Department of Labor (U.S. DOL) to include workers employed by a harvesting crew of a canner, processor, packer, or independent contractor, or employees of a chicken factory or hatchery if they are employed on a farm and doing work that is primary or secondary agriculture. Minor and incidental aspects of their job, such as transporting equipment, do not alter this designation. *See* 29 C.F.R. 780.136. The U.S. DOL also has specific rules relating to several subcategories of agriculture-related operations/products, such as nurseries and florists, Christmas trees (and wreath making), and

[3] "Agriculture" includes farming in all its branches and among other things includes the cultivation and tillage of the soil, dairying, the production, cultivation, growing, and harvesting of any agricultural or horticultural commodities, the raising of livestock, bees, fur-bearing animals, or poultry, and any practices (including any forestry or lumbering operations) performed by a farmer or on a farm as an incident to or in conjunction with such farming operations, including preparation for market, delivery to storage or to market or to carriers for transportation to market.

[4] "[A]ny employee employed in agriculture . . . (C) if such employee (i) is employed as a hand harvest laborer and is paid on a piece rate basis in an operation which has been, and is customarily and generally recognized as having been, paid on a piece rate basis in the region of employment, (ii) commutes daily from his permanent residence to the farm on which he is so employed, and (iii) has been employed in agriculture less than thirteen weeks during the preceding calendar year . . . ." FLSA Section 213(a)(6)(C).

pine straw, which should be carefully reviewed if your operations include any of these operations and/or products. Please note this is not an exhaustive list of specific rules, and if you have questions on how the federal rules relate to your farm or operation, we recommend reaching out to an attorney to address your questions and concerns.

New England State Exemptions to Overtime

State	Exempt from overtime laws?	Applicable state laws	Further Information
Connecticut	Yes	CONN. GEN. STAT §§ 31-76c, 76i(k)	
Maine	Yes	26 M.R.S. §§ 663(3)(A), 664(3), 1043(1)	However, overtime is required for egg processing facility that has over 300,000 laying birds.
Massachusetts	Yes, but strict restrictions on exemption	M.G.L. c. 151, § 1A	See below for further discussion of current laws. Also, pending legislation may impact overtime for agricultural workers (see below for further details).
New Hampshire	Yes, for seasonal establishments	N.H. R.S.A. § 279:21	"Seasonal establishments" either do not operate for >7 months in any calendar year or during the preceding calendar year, average receipts for any 6 months were not >33.3% of its average receipts for the other 6 months of such year.
Rhode Island	Yes	28 R.I. GEN. LAWS §§ 12-4.1, 4.3(a)(9)	See 28 R.I. GEN. LAWS §§ 12-4.3(a)(9) for specific exemptions relating to agricultural enterprises
Vermont	Yes	VT. STAT. ANN. tit. 21, § 383(2)(A), 384(a)-(b)	See below for more information about Act No. 117 (relating to efforts for seasonal workers collective bargaining).

Massachusetts

In Massachusetts, an employer only triggers the obligation to pay overtime when they employ someone in an "occupation" for more than 40 hours in a work week. Following a 2019 decision, the Supreme Judicial Court instructs that "planting, growing and harvesting" activities fall within the definition of "agricultural and farm work," which consequently are not considered an "occupation" that would trigger overtime requirements. However, post-harvesting activities, are not "planting, growing and harvesting," and are considered an "occupation" for overtime purposes. With this standard, what is the overtime obligation for a farmer who employs a farm worker that splits their time between planting, growing, and harvesting and post-harvesting activities?

At this time, employers are obligated to track an employees' activities and meet overtime obligations for any hours the employee performs work outside the definition of "planting, growing and harvesting." For example, if Worker A performs 55 hours of work in one week and spends 15 hours planting, growing, and harvesting, and 40 hours working at a farm stand and/or performing farm maintenance activities, only 15 hours are exempt from overtime, but no overtime is owed to Worker A because the remaining time did not exceed 40 hours. If Worker B, however, performs 45 hours of work in one week, but all 45 hours were spent on transportation, farm maintenance, inspecting, sorting, weighing, packaging, or other post-harvesting activities, then no hours are exempt from overtime and Worker B should receive overtime pay for the 5 hours above the standard workweek. *Please note that overtime applicable to blended rates of pay must represent the "regular rate of pay" for the non-overtime-exempt work performed.*

Importantly, earlier this year, the House and Senate directed the House's Committee on Revenue to investigate and study several bills, including Senate Bill 1837, which relates to agricultural workers (including required overtime rate after 55 hours of work (seasonal employees) and 40 hours of work (full-time employees)), and to draft legislation necessary to carry out any recommendations following its investigations. Such draft legislation, if any, is due to be submitted by the end of this calendar year. As such, employers in Massachusetts should keep a close eye on the potential forthcoming updates to overtime regulations in Massachusetts.

Please note that Massachusetts currently offers seasonal employers (not more than 120 days per year) the ability to seek an overtime waiver (cost $200 per application), through the Commonwealth of Massachusetts' Executive Office of Labor and Workforce Development.

Vermont

Act No. 117, effective July 1, 2024, created, among other things, the Agricultural Worker Labor and Employment Laws Study Committee to study the labor and employment laws that apply to Vermont agricultural workers, to develop a proposal for legislation to permit Vermont agricultural workers to collectively bargain, and to identify additional potential changes to labor and employment laws in relation to agricultural workers.

On August 27, 2024, the Committee met for the first time and continues to meet about once per month. The next meeting scheduled is November 15, 2024. You can watch the meeting via

livestream on the Vermont Legislative Study Committees' YouTube page.[5] You can also find documents and handouts on the Vermont General Assembly website.[6]

Other Notable Laws

Although our presentation will not discuss the Migrant and Seasonal Agricultural Worker Protection Act (MSPA), and the H-2A and J-1 visa programs, we want to highlight that these laws may be applicable to your operations, and you should reach out to your legal counsel if you have questions as to how these laws may apply to your farm.

MSPA

The MSPA establishes basic protections related to housing and employment for covered migrant and seasonal agricultural workers. MSPA applies only to certain agricultural employers, agricultural associations, farm labor contractors, and agricultural workers. There is a family business and small business exemption (fewer than 500 man-days).

H-2A

The H-2A visa program allows an employer to hire temporary, non-immigrant workers to perform agricultural labor or services of a temporary or seasonal nature. There are certain obligations for employers utilizing this program, such as pay rates, written disclosures, housing, transportation, guarantees, inbound and outbound expenses, and others.[7]
On April 29, 2024, the U.S. DOL published a final rule regarding the H-2A visa program, which states that, if applicable, the employer must state that overtime hours may be available, the wage rates for such overtime, how the wage rate will be paid, and the law requiring the overtime pay. If this program applies to your operations, we recommend you review the final rule, and connect with your legal counsel if you have any questions regarding the impact to your operations.

J-1

The J-1 visa program is not a work visa program, but can be used for cultural exchange work-experience programs, such as sharing American agriculture as an agribusiness/agricultural host.

[5] https://www.youtube.com/channel/UCQXkUCDAVlCkzSdNeipFDkA/featured.
[6] https://legislature.vermont.gov/committee/detail/2024/389.
[7] https://www.dol.gov/agencies/whd/fact-sheets/26-H2A.

Growing Great Garlic

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As the garlic industry in the northeast has expanded the number of issues garlic growers face has kept pace. This once carefree crop now requires more attention and care than it historically did to yield a high quality, long-storing final product. Research on all aspects of garlic production has reinforced some key cultural practices that can help growers attain and then maintain great garlic from year to year. This presentation and article highlight some of those findings.

Selecting seed stock: No state in the northeast has a clean seed program, but many growers who sell seed garlic send in samples to screen for white rot *(Stromatinia cepivora*, formerly *Sclerotium cepivorum)* and garlic bloat nematode *(Ditylenchus dipsaci).* Selecting seed which is free of these persistent problems is essential. Another seedborne disease, Fusarium, has been found to be much more widespread but also can be controlled with good cultural practices discussed later in this article. Additional diseases, such as botrytis neck rot and surface molds, are airborne and may enter a farm regardless of the quality of the seed. However, cloves that show degradation from any of these issues should be discarded when separating cloves to plant.

Most growers choose to plant seed from medium to large bulbs, which will in turn yield medium to large bulbs. Small bulbs will at best yield medium bulbs in the following year. Growers may also cull the small cloves from a large bulb, since these may not have the energy to produce large bulbs.

A pre-plant dip in a surface sterilizer such as Oxidate at the labelled rate will kill any spores on the surface of the clove but will not control diseases that penetrate the clove surface. If dipping garlic, do so immediately before planting. Hot water treatment is not recommended due to the difficulty in doing so correctly.

Soil preparation and fertility: Garlic grows well in many soil types if the strengths and limitations of the soil are accounted for. Growers who are on clay soils tend to plant very shallowly, sometimes not even covering the whole clove with soil, and then use organic mulches to provide coverage and a good medium for the bulb to expand into. Growers on sandy soils will often plant the garlic up to two inches deep to increase moisture access. One of the interesting discoveries that we made during our Fusarium cultural control trials was that even on extremely well-drained soils a frost layer in the ground can lead to ponding in the field. If that standing water is at the same level as the garlic and freezes and thaws with the garlic encased in it, significant damage is likely. For this reason, we recommend planting garlic on raised beds even if you are on well-drained soil.

Fertilizer application rates for garlic have historically been based on onion rates. We have not tested phosphorus and potassium levels but have tested nitrogen levels and have modified them based on our research. In order to gain a simplified snapshot of how much nitrogen garlic needs we completed two replicated studies in 2017 and 2018 using a synthetic version of ammonium

nitrate applied in the spring as garlic began to grow. These studies, conducted on the Long Island Research Farm and at two sites in Western New York, showed that garlic only takes up about 50 pounds of nitrogen during the growing season. Weeds or the next crop took up remaining nitrogen. Residual available nitrogen, plus the lush microbial life developed by the garlic crop, are compelling reasons to follow garlic with a fall brassica or a cover crop.

For organic growers garlic fertility is a bit trickier than many other crops because garlic begins growing so early in the spring. The speed at which organic forms of nitrogen are broken down by microorganisms into forms the plant can use (mineralization) depends on a combination of the biological activity of the soil and the soil temperature. Garlic starts growing when soil temperatures move above about 40°F, but mineralization is optimized at 68°F. This leads to a lag between growth and availability. The seed itself provides the first nitrogen to the growing plant, but this runs out relatively quickly, depending on the seed size. Because of this lag we recommend supplying 100 lbs of fall-applied nitrogen, with the assumption that not all of it will become available while the crop is utilizing it. Applying this rate of fertilizer in the fall eliminates the need for a spring application of fertilizer in our studies.

Cultural considerations that help maximize a garlic crop: The next natural consideration in building a good garlic system is to decide whether or not to cover the crop with a mulch. The best cover for garlic is a complex question that must take into account soil types, equipment availability, irrigation, and weed control. One of the most interesting studies we've done to date examined all the covers garlic growers commonly use, from bare ground (no cover), to straw/hay mulch, to white and black plastics. With each of these treatments we examined yield, size, and disease severity in replicated trials at two farms in two seasons.

The average weight per bulb metric showed black plastic providing the highest yield, followed by white plastic, bare ground, and then straw. Black, white, and bare ground did not have statistically significantly different yields, but were numerically different, with black plastic averaging 15 pounds per hundred bulbs, white averaging 14 pounds per hundred bulbs, and bare ground averaging 13.6 pounds per hundred bulbs. Straw mulch was significantly lower, with an average weight of 12 pounds per hundred bulbs.

We know from taking temperatures in the various beds in spring that the black plastic treatment warmed the fastest, followed by bare ground, with white plastic and straw lagging behind a bit. This early warming certainly made nitrogen available to the garlic sooner and led to plants growing noticeably larger, earlier. However, black plastic may be able to warm the ground too much during the later season, effectively shutting the plant down during the day by taking soil temperatures over 90°F. Straw mulch, by contrast, stayed cool much longer and also has the potential to stay wetter than the plastic treatments, both factors in slowing early nitrogen availability. However, in a dry year such as the one we're wrapping up now, straw mulch provides needed moisture holding capacity, as does plastic. Notably, the straw mulch treatment had the lowest incidence of *Fusarium* in our trials.

All mulch treatments reduce or eliminate mechanical weed control, though most require some hand weeding. Weighing the economics of these mulches against a row-crop system with mechanical weeding and/or herbicide applications can be difficult because the systems are so

different. Often the decision comes down to space availability and grower systems. If choosing to grow garlic organically in a bare ground system, expect to cultivate an average of 6 times in the growing season, and use cover crops in the preceding season to reduce the weed seed bank if possible. Poor weed control may reduce garlic yields by 30% and increases humidity around the plants, inviting airborne disease issues.

Post-Harvest Handling Considerations: As previously reported at the NEVF conference, garlic tops may be cut at harvest with no ill effects and doing so will save significant time and drying space. Placing garlic in a warm environment such as a high tunnel with shade cloth reduces drying time and may reduce the window for secondary diseases like black mold (*Aspergillus*) to form. Once garlic is fully dry, as indicated by the innermost wrapper leaf being completely dry to the touch, garlic can be moved to a storage location which is ideally kept at 70° F and 70% relative humidity for storage until planting.

Our emerging research on post-harvest handling deals with management of eriophyid mites (*Aceria tulipae*), a leading cause of damage in garlic internationally for decades but an emerging issue in the United States. Eriophyid mites cause feeding damage primarily after the garlic has been cured and is being stored at room temperature. Look for brown, shrunken cloves which are lighter than others. Peeled cloves may have a powdery or sparkling coating on the surface. High magnification (40x or more) may show tiny cigar shaped insects, particularly on the inside of the wrapper leaf.

Our initial work has shown mixed results with control measures. Our study deploying predatory mites in storage yielded good control only once mite populations were relatively high and were causing economic damage. More work to determine ideal timing and if faster control is possible is needed. Our work confirmed that varieties with looser wrapper leaves such as Rocamboles are more susceptible to mite infestations than the harder to peel varieties such as Porcelain and Silverskins.

Previous research by Courtin et al. showed that eggs could be killed when garlic was kept at 113°F for one hour. The application of heat at the end of the drying process shows a great deal of promise but may not kill all mites located on the inside of the bulb. Garlic should be examined periodically in storage for signs of damage even after this step. If damage begins to develop, storage at or below 43°F will pause mite activity and stop damage from progressing.

Mites may survive in the soil and reinfest garlic, particularly if the soil is relatively dry over winter. Saturated soils will kill eriophyid mites; therefore, wet falls and springs benefit garlic growing when mites are a concern.

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New Hampshire Spotted Wing Drosophila on-Farm Exclusion Netting Demonstration Project

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Stark Farm is a PYO organic highbush blueberry farm. We have never sprayed our 350 bushes with any pesticides, fungicides, or herbicides. Initially our field was enclosed with a Smart Net Bird Netting system to protect the crop from aerial predation. This netting was deployed across an overhead network of high-tensile wires supported by wood posts. At each end of the field H-Frame posts added the necessary overall structure.

In 2021, our growing season was impacted by Spotted Wing Drosophila (SWD), ultimately destroying the second half of our season. Stark Farm was at a crossroad, faced with the following choices; continue farming by converting to spraying for SWD with conventional pesticides, investigate retrofitting, and the cost associated with installing exclusion netting, or stop farming altogether. At this juncture, we chose to apply for a Conservation Innovation Grant.

In 2021, Rockingham County Conservation District in partnership with the University of New Hampshire Cooperative Extension, awarded Stark Farm a Conservation Innovation Grant from the United States Department of Agriculture – Natural Resources Conservation Services for a cost sharing project to retrofit our existing Smart Net Bird Netting over to an Exclusion Netting System.

With funding approved in December of 2021, planning commenced immediately to ensure installation would be complete prior to opening in July 2022. Our team consisted of the following representatives:

- Tek-knit Industries, Montreal, Canada – Manufacturer of the exclusion netting
- Gintec Shade Technologies, Inc., Ontario, Canada – Manufacturer of structural materials
- The Berry Patch, Stephentown, NY – US Distributer for Tek-knit/Gintec system
- Jeremy Delisle - University of New Hampshire Extension
- Chris Callahan – University of Vermont Extension

To guarantee the accuracy of retrofitting to exclusion netting the team held numerous conference and/or zoom calls for upfront planning details. Stark Farm provided a detailed scaled drawing of the current bird netting system structure (approximate field size = 30,000 square feet). This allowed the team to determine the appropriate additional structural upgrades, along with providing final measurements for the manufacturing of the exclusion netting. The upfront planning, collection of information, and detailed team review is the most critical steps required for a successful retrofit.

All materials for this project were received at Stark Farm in early to mid-June of 2021, giving us two weeks to complete the retrofit installation in time for our opening, and also ahead of the

emergence of Spotted Wing Drosophila. Jeremy Delisle and Chris Callahan (UNH & UVM Extension) were on-site for technical assistance, along with HMP Fence Co, and Chip & Maria Donnelly, owners of Stark Farm. Installation was completed by July 1, 2021.

Following is a breakdown of costs associated with this project:

• Exclusion Netting	$9,426.65
• Structural Materials	$2,124.12
• HMP Fence Co Installation & Labor	$6,823.98
• Perimeter/Border Materials	$1,634.66
• Misc. Hardware, lumber, etc.	$1,243.56
Total:	$21,252.97

On-going management and efficacy

We just completed our third season with the exclusion netting system. As a result, we have been able to continue farming organically, while never spraying our crop. The Exclusion Netting has been 100% effective in keeping SWD from entering our blueberry field. We continually monitor our Trece SWD insect traps throughout the harvest season and have not one capture to date within our netted field.

In order to have these results we must be diligent in our overall inspection and maintenance. Rolling out and in our netting system annually, along with weather events can cause wear and tears in the netting. Immediate attention to repairing any openings is critical in keeping SWD out of our field. There are no repair kits to our knowledge, leaving us with having to hand stitch additional netting (using fishing line) over any of these breaches. To properly protect the net at the end of the season, once the netting is rolled back and secured to the cables, we wrap the entire net with black UV pallet wrap

Managing perennial weeds in perennial cropping systems

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Creeping perennial weeds survive from year to year and spread via rhizotomous or spreading roots. These weeds often become established in perennial cropping systems. Several difficult perennial weeds common in the Northeast include:

- Canada thistle (*Cirsium arvense*)
- Field bindweed (*Convolvulus arvensis*)
- Hedge bindweed (*Calystegia sepium*)
- Horsenettle (*Solanum carolinense*)
- Oriental bittersweet (*Celastrus orbiculatus*)
- Poison ivy (*Toxicodendron radicans*)
- Quackgrass (*Elytrigia repens*)
- Yellow nutsedge (*Cyperus esculentus*)

The easiest way to manage perennial weeds is to kill them before planting a crop. If possible, choose a site that is free of perennial weeds. Otherwise, spend a year or two preparing the site by managing the perennial weeds through a mix of methods, including:

- systemic herbicides, tillage, cover cropping, tarping, and/or mowing.

Once the crop is planted, manage perennial weeds by preventing their establishment. Ensure all inputs to the farm are weed-free. Weed propagules (seeds or root fragments) are often brought onto a field through:

- mulch, compost, farm equipment, contaminated seed, and bird droppings.

If you notice a perennial weed seedling, kill it before it has time to become established. If there is an established patch of perennial weeds in your field, focus first on containing growth by preventing further spread.

To kill creeping perennials, target root growth either mechanically or chemically. To mechanically target root growth, repeatedly remove aboveground growth, ideally, when the most resources have been used to form new shoots and before energy from photosynthesis is being sent back to the roots. This process will likely need to be repeated for several years before sufficiently exhausting root reserves.

To kill the weed chemically, consider incorporating a post-emergent systemic herbicide into your spray schedule. These herbicides enter the phloem of the plant and can be transported down into the roots. To improve efficacy of post-emergent systemic herbicides:

- Make sure the pH of your spray water is slightly acidic so that the herbicide can enter the plant.
- Add any recommended surfactants so that the herbicide remains on the plant leaf long enough to enter the vascular system.
- Do not apply with a fast-acting burn-down herbicide or the systemic herbicide will not have time to enter the plant and travel to the roots.
- If possible, apply in the fall when plants are sending resources to their roots for winter-storage and survival. This timing will help bring the herbicide to the roots.

Here are some post-emergent herbicide options to consider incorporating into your spray schedule to target creeping perennial weeds in blueberries. Always check that the product is labelled for use in your state and apply according to the label directions.

Post-emergent systemic herbicides that help control common creeping perennial weeds in Northeast blueberry fields.

Active Ingredient *Product name*	Rate (per/A)	Weeds controlled	Application instructions
Sethoxydim (Group 1) *Poast*	1- 2.5 pt	Grasses, including quackgrass	Do not apply to grasses under stress (e.g. drought). Crop oil concentrate must be added to spray tank. Do not cultivate 5 days before or 7 days after application. Do not exceed 5 pt/A/yr.
Clethodim (Group 1) *Select Max*	9-16 oz	Grasses, including quackgrass	Do not apply to grasses under stress (e.g. drought). Apply as a directed spray to the base of the blueberries. Apply with a non-ionic surfactant at 0.25% v/v. Do not repeat applications within 14 days. Do not apply more than 64 oz/A/yr.
Halosulfuron -methyl (Group 2) *Sandea*	0.75-1 oz (bushes >4 yr)	Yellow nutsedge	Apply once when nutsedge is fully emerged, or twice when the first flush and then the second flush has reached 3-5 true leaves. Apply as a directed shielded spray to the ground on either side of the row in a minimum of 15 gal water/A. Avoid contact with the blueberries.
2,4-D (Group 4) *Embed Extra*	3 pt	Many broadleaf weeds, including Canada thistle	Make a directed or shielded spray in the spring or to row middles after harvest in the summer or fall. Do not apply more than 6 pt/A/yr. Only 1 application preharvest and 1 application postharvest per year. Do not allow contact with blueberry foliage.

Quinclorac (Group 4) *Quinstar*	12.6 oz	Canada thistle, field bindweed, & hedge bindweed	Apply at the end of dormancy, prior to budbreak. A second application can be made up to 30 days prior to harvest. Apply to the ground as a banded spray on either side of the blueberries. Apply with a crop oil concentrate at 2 pt/A. Do not apply to crops under stress (e.g. hail, flooding, drought) or crop damage may occur.
Glyphosate (Group 9) *Roundup Power Max*	1 - 5 qt	most plants, including Canada thistle, field bindweed, horsenettle, oriental bittersweet, poison ivy, & quackgrass	Apply to actively growing weeds. Apply with a wiper, as a spot treatment, or with a completely shielded sprayer to the base of the plants. Nonionic surfactans can be added, especially if the carrier volume is above 30 gal/A or the application rate is below 15 oz/A. Ammonium sulfate at 1-2% dry weight (8.5-17 lbs/100 gal water) can increase performance. Do not permit herbicide to contact desirable vegetation, including green shoots, canes, or foliage. Do not cultivate within 7 days after application.

Bumblebees and Blueberries

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Wild bumblebees (*Bombus* sp.) are native, generalist pollinators that contribute to the fertilization of native forbs and enhance the yield of field, fruit, and seed crops. Specifically, pollination of over 25 agricultural crops can be attributed to pollination efforts performed by bumblebees, including blueberries, strawberries, zucchinis, melons, sweet peppers, and tomatoes. For these crop species, the bumblebees' "buzz" pollination strategy and comparatively lower sensitivity to wet and cold weather conditions make them better pollinators than domesticated honeybees (*Apis mellifera*). As a specific example, because the blueberry blooming period temporally overlaps with bumblebee queen foraging flights in the spring, there is a mutualistic relationship where bumblebee queens are responsible for blueberry yield and blueberry floral resources are responsible for supporting bumblebee colony establishment and nest success. In Connecticut, 229 farms grow blueberries for local consumption; average yield across these farms fluctuated between 1,440 and 2,530 lbs/acre from 2017-2022. Increased bumblebee queen abundance would ensure high blueberry yield; however, although the resources provided by the blueberry's short 3-to-4-week bloom period are enough to assist the queen with establishing a nest, additional resources are needed to sustain the bumblebee's complete lifecycle and facilitate population growth.

For the past several decades, pollinating insects, including bumblebees, have been on the decline. Generally, habitat loss and fragmentation are considered to be the most important drivers of the population declines. Currently, most conservation efforts for pollinators aim to provide forage habitat with floral resources from May-October; however, these efforts may not be providing needed nesting and overwintering habitat. To help support blueberry farmers and production of other pollinator-dependent crops, understandings of suitable nesting, foraging, and overwintering habitats for bumblebees and their ability to navigate between small habitat patches across Connecticut's fragmented landscape are needed. Currently, we do not have robust descriptions of nesting and overwintering habitat needs and lack understanding of landscape-scale resource-searching behavior. This presentation will describe research being conducted to determine how landscape composition surrounding forage habitats influences space use for nesting, foraging, and overwintering. The goal of this work is to provide guidelines for blueberry producers to increase bumblebee queen abundance in the spring to enhance crop pollination.

Beetles, Aphids, and Flies in Blueberries

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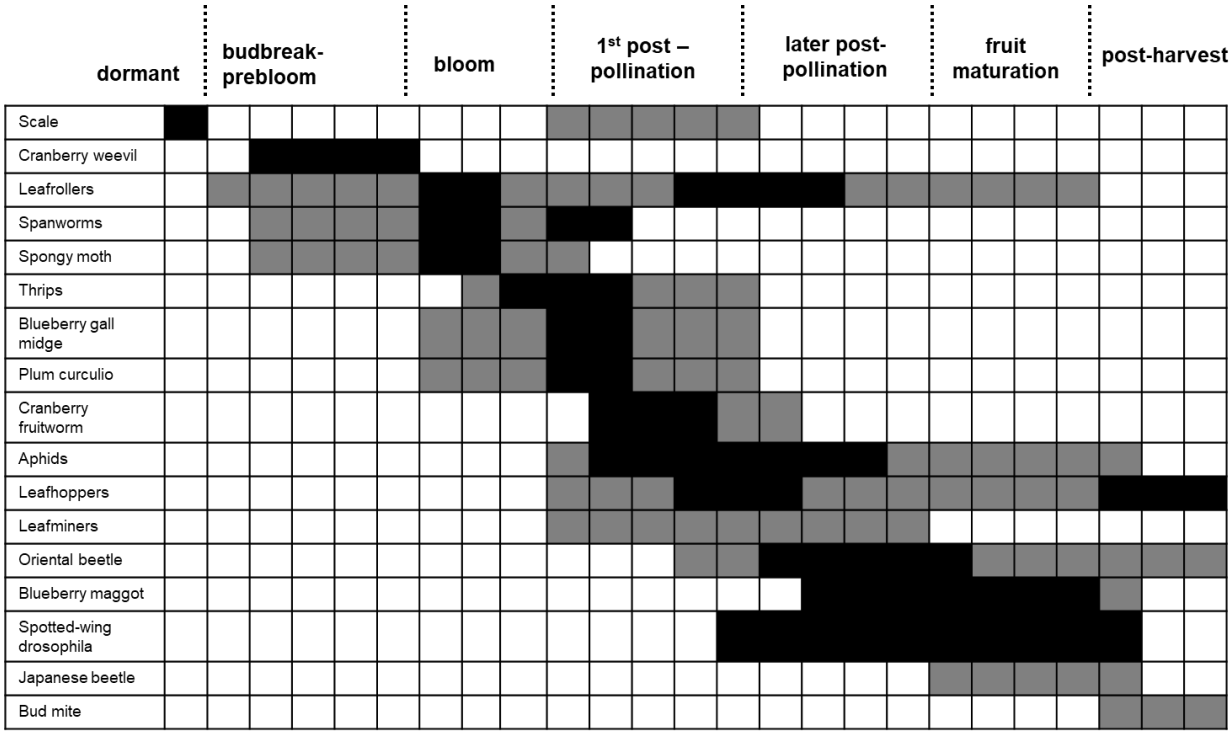
Highbush blueberry production in New Jersey, USA, is concentrated primarily in the southern part of the state, in an area known as the Pinelands or Pine Barrens, a designated national reserve. Of the approximately 16 insect pests that affect highbush blueberries in New Jersey (Figure 1), three are of primary concern: plum curculio (*Conotrachelus nenuphar*), blueberry aphids (*Illinoia* spp.), and spotted-wing drosophila (*Drosophila suzukii*).

Figure 1. Seasonal activity period of blueberry insect and mite pests in New Jersey. Bars show period when scouting (grey color) and management (black color) of the pest is most important.



Each of these three pests presents unique management challenges: plum curculio adults are active during bloom, a time when insecticide applications are restricted; aphids hide on the undersides of leaves, complicating spray coverage; and spotted-wing drosophila is particularly challenging to manage due to its high reproductive capacity, multiple generations per year, and lack of effective biological control agents in the regions it has invaded. Below, we summarize our ongoing research aimed at enhancing management strategies for these key pests.

Plum Curculio

Plum curculio adults damage the blueberry fruit while still green. To manage them, insecticides are applied immediately after commercial honey bees are removed from the fields. In New

Jersey, the primary insecticides recommended for controlling plum curculio are indoxacarb (Avaunt®) and phosmet (Imidan®) (Besançon et al. 2022). However, managing plum curculio is challenging because this pest is active during bloom, a period when insecticides cannot be used due to the presence of honey bees. This is especially problematic in early-maturing blueberry varieties.

To address these limitations, recent research has explored behavioral and biological control alternatives targeting both adult and immature stages of plum curculio. A "trap bush" approach has been tested to aggregate adult plum curculio damage in specific areas (Rodriguez-Saona et al. 2019). This strategy uses attractive baits, containing the aggregation pheromone grandisoic acid and the plant volatile benzaldehyde, to lure adult plum curculio to designated sections of the field, usually perimeter bushes. Control measures can then be applied to these targeted areas, rather than the entire field.

Additionally, biological control using entomopathogenic nematodes has shown promise in targeting plum curculio larvae in the soil. Four commercially available entomopathogenic nematode species—*Steinernema feltiae*, *S. carpocapsae*, *S. riobrave*, and *S. scarabaei*—were tested at a rate of 50 infective juveniles (IJs)/cm². Emergence traps with plum curculio-infested berries revealed that *S. riobrave* was the most effective at reducing adult emergence, persisting in the soil for up to 21 days under field conditions (Sousa et al. 2021). Further testing of *S. riobrave* at both 50 and 25 IJs/cm² showed significant reduction in plum curculio emergence compared to untreated controls, with similar rates of suppression at both dosages (Sousa et al. 2021). Future studies will evaluate the efficacy and persistence of *S. riobrave* in commercial blueberry fields.

Blueberry Aphids

Several aphid species affect highbush blueberries in New Jersey, including *Illinoia azaleae*, *Aphis fabae*, *Ericaphis fimbriata*, and *Myzus persicae*, with *I. azaleae* being the most abundant. Aphids are known vectors of viruses like the blueberry scorch virus. Although they may appear during bloom, insecticide applications must wait until honey bees have been removed from the fields. In New Jersey, treatment is recommended when more than 10% of blueberry terminals are infested with live aphids. The primary insecticides used for aphid control in blueberries are neonicotinoids, including acetamiprid (Assail®), imidacloprid (Admire® Pro), and thiamethoxam (Actara®) (Besançon et al. 2022). However, concerns about potential non-target effects have led to restrictions on neonicotinoid use.

New insecticides with alternative modes of action have been registered for use in blueberries, including Movento® (spirotetramat), Sivanto® (flupyradifurone), and Senstar® (pyriproxyfen + spirotetramat). These insecticides were recently tested alongside Assail® (acetamiprid) and an untreated control. Results showed that aphid mortality was significantly increased after five days of exposure to these insecticides.

Spotted-Wing Drosophila

Spotted-wing drosophila, an invasive pest first detected in New Jersey in 2011, attacks a wide range of thin-skinned fruits, including blueberries, strawberries, raspberries, and cherries. Currently, control of this pest relies primarily on nearly weekly, calendar-based insecticide

applications during fruit ripening (Besançon et al. 2022). To reduce the risk of resistance, it is recommended to rotate insecticides with different modes of action.

Ongoing efforts are focused on developing effective behavioral and biological control strategies for spotted-wing drosophila. Two behavior-based products currently under evaluation are ACTTRA SWD® and Combi-protec®. ACTTRA SWD® (ISCA Technologies Inc., California, USA) combines an attractive volatile blend (chemical cues) with visual cues and a phagostimulant that can be mixed with an insecticide to attract and kill spotted-wing drosophila. Combi-protec® (Andermatt Group AG, New Jersey, USA) acts as an adjuvant feeding stimulant that can be mixed with an insecticide but lacks an attractant.

Additionally, a permit to release *Ganaspis kimorum*, a parasitoid native to Asia that is well-adapted to target spotted-wing drosophila larvae, was recently approved in the US. From 2022 to 2024, 25,000 *G. kimorum* wasps have been released in wooded areas near blueberry fields in New Jersey, with the goal of establishing a sustainable population to help control spotted-wing drosophila. Current research in New Jersey includes studying the overwintering biology of *G. kimorum*, along with continued releases and monitoring to track its establishment and impact.

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Novel Behavior-Based Strategies for SWD

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The spotted-wing drosophila (SWD), *Drosophila suzukii* (Matsumura), is an invasive pest from Southeast Asia, first detected in the continental U.S. in 2008 (Tait et al. 2021). SWD infests various thin-skinned, soft fruits, including blueberries, strawberries, raspberries, and cherries. Current management primarily relies on calendar-based insecticide applications, highlighting the need for alternative strategies to reduce reliance on insecticides. Our research focuses on developing effective behavioral control methods for SWD, including attract-and-kill strategies, feeding stimulants, push-pull tactics, and the discovery of novel repellents.

Attract-and-Kill Strategies

A behavior-based product under evaluation for SWD management is ACTTRA SWD® (ISCA Technologies Inc., California, USA). This product combines an attractive volatile blend (chemical cues), visual cues, and a phagostimulant, which can be mixed with an insecticide to attract and kill SWD adults. Laboratory studies have shown that ACTTRA SWD® effectively controls SWD (Babu et al. 2022a; Babu et al. 2023), though its efficacy is influenced by internal factors (e.g., insect physiology) and external factors (e.g., availability of host fruits) (Babu et al. 2022b).

Feeding Stimulants

Combi-protec® (Andermatt Group AG, New Jersey, USA) is a feeding stimulant that enhances insecticide efficacy when combined with an insecticide. Laboratory studies show that Combi-protec® is neither attractive nor repellent to adult SWD, and that its addition to various insecticides does not alter adult behavioral responses to the spray solution. When added to acetamiprid or cyantraniliprole spray solutions, Combi-protec® resulted in quicker adult mortality. However, no significant reduction in larval infestation was observed compared with insecticide-alone treatments. In laboratory and field trials conducted in New Jersey and other states, Combi-protec® achieved mortality levels comparable to full-rate insecticide applications and showed similar effectiveness when applied at half-rate compared to full-rate insecticide alone.

Push-Pull Strategies

A "push-pull" strategy for SWD involves using a repellent to drive adults away from crops (push) while attracting them toward a baited mass trapping device (pull). Laboratory tests revealed that methyl benzoate, a naturally occurring plant compound and FDA-approved food additive, is repellent to SWD. Field trials showed that methyl benzoate significantly reduced SWD infestation rates in blueberries, particularly under high pest pressure (Gale et al. 2024). However, mass trapping devices alone did not offer comparable protection or enhance effectiveness when combined with methyl benzoate. Thus, methyl benzoate shows promise as a spatial repellent for SWD without requiring an attractant.

Novel Repellents

Research has shown that SWD avoids blueberries infected with the fungal pathogen *Colletotrichum fioriniae*, which causes anthracnose fruit rot (Urbaneja-Bernat et al. 2020), leading to the identification of nine potential repellents (Rering et al. 2023). Of these, ethyl butanoate and ethyl (*E*)-but-2-enoate were tested further. Electroantennogram (EAG) assays revealed that both esters elicited strong, dose-dependent antennal responses in SWD, surpassing responses to the known repellent 2-pentylfuran. Field trials using caged blueberry plants demonstrated that ethyl butanoate, ethyl (*E*)-but-2-enoate, and 2-pentylfuran significantly reduced SWD oviposition and adult emergence, with ethyl (*E*)-but-2-enoate sometimes outperforming the others. These findings suggest that these esters, particularly ethyl (*E*)-but-2-enoate, are effective oviposition deterrents and may serve as valuable repellents in SWD management.

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The Farmer Spreadsheet Academy

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In this day of apps and specialized websites, it can be quite nice to simply use a good old spreadsheet to manage your farm. A spreadsheet that you can easily tweak or update to fit your particular situation. This is especially true for Crop Planning.

You can access the crop plan template used in this session at www.spreadsheet.farm/bcp. (Make sure to choose the 2025 template!) Pivot Tables are one of the key spreadsheet tools in this template and let you dynamically create easy to reference reports and schedules.

The Farmer Spreadsheet Academy Crop Plan can be used to plan out all types of crops from vegetables, to flowers, to seed crops, and more. And it can be used to plan for farmers markets, CSA baskets, or online sales. Here are the general steps:

1. Set your $/bedft targets on the Space Benchmarks tab
2. Forecast what you plan to sell on the Sales Plan tab.
3. Then you can jump into the Crop Planner tab to figure out how much to grow and when to plant
    - White columns A-C are what crops you plan on growing
    - Orange columns D-L turn your sales plan into harvest needs
    - Blue columns M-Z are where you plan how you will grow in the field
    - Green columns AA-AM are where you plan your nursery operations
    - Purple columns AN-AO calculate how much seed you will need.
4. Once your information is in the crop planner tab, Pivot Tables automatically create a series of Schedules and Charts:
    - Your Sale Plan by item list or by forecasted sales
    - Your field planting schedule
    - Your nursery schedules
    - Your seed needs

This Crop Plan template is simple to use yet quite complex in what it lets you plan for your farm. is fully customisable and flexible. That is what the Farmer Spreadsheet Academy is all about!

What is Probate? How to Avoid It for Your Farm

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Do I Need to Open Probate?

Probate Court was designed so that there is a consistent process to wrap up the affairs of someone who passes away owning assets. For example, if you own a car and want to give it or sell it to someone, you must sign a bill of sale and/or the title to transfer the car to them. If you pass away, you are no longer able to sign the necessary documents. The Probate Court appoints an Executor so that someone would be able to sign the necessary documents to give or sell the asset for the person who passed away. The Probate Court process also creates a consistent process so that people who are owed money know what to do to get paid, and to keep track of what happens with assets to try to prevent them from being lost.

Clear signs that you will need to open Probate are:
You will need to open Probate if: Someone has asked for your "Letters of Testamentary", "Letter of Appointment", or "Court Paperwork"; A financial institution is telling you that you need to open an "Estate Account" and need a "Tax ID number"; You cannot get information about the person's accounts or sign checks for their accounts; and/or, you do not have "authorization" to sign necessary document to sell or donate an asset belonging to the person who passed away.

Please note: A Durable General Power of Attorney terminates at the death of the principal, so even if you had access to the accounts with this document prior to the person's death, at the person's death that access ends.

You may not need to open Probate if:
If all of the persons bank accounts and were held Jointly with another person, there were "Transfer on Death" or "Beneficiary" designations, or the assets were held in a Trust, and the person wrapping up the affairs of the person who passed has complete ability to access all of the assets, then you may only need to file the Last Will & Testament and not "open Probate". Even if the majority of the persons assets were held in Trust, had Joint Owners, or Beneficiary Designations, there are still some instances where Probate becomes necessary.

I have a Last Will & Testament, doesn't that avoid Probate Court?

A Last Will & Testament is a document that is created for the purpose of directing where someone's assets are going to go if they pass away. The person who creates the Last Will & Testament is the Testator (or Testatrix if they are female). The Testator decides where their real estate, cars, bank accounts, and personal items are going to go if they pass away. The Testator also chooses a person to make those transfers, that person is called the Executor (or Executrix if they are female).

A Last Will & Testament is just paper, without any power, until it is filed with the Probate Court. The Will is supposed to be filed within thirty (30) days of the Testator passing.[8] When a Last Will & Testament is filed with the Probate Court, the Probate Court Judge will review the document for legality and make the decision to appoint the Executor. It is the job of the Executor, once appointed, to gather and safeguard all of the assets of the person who passed away. They are also responsible for determine the creditors of the estate, paying the bills of the Testator from the assets in the estate, and then accounting for all of the assets and payment of bills during the time they are the Executor.[9] Usually the entire process takes about one (1) year.

Yes, you understood correctly! A Last Will & Testament MUST go to Probate Court and a Probate Court Judge MUST appoint the Executor. Probate Court is designed so that there is a consistent process to wrap up the affairs of someone who passes away owning assets. For example, if you own a house and want to give it to someone, you must sign a real estate deed to transfer the house to them. If you pass away, you are no longer able to sign the real estate deed. The Probate Court appoints an Executor so that someone would be able to sign the real estate deed for you. The Probate Court process also creates a consistent process so that people who are owed money know what to do to get paid, and to keep track of what happens with assets to try to prevent them from being lost.

So, what did it mean when you heard someone say "Oh, you have a Will, you are all set."? It meant that you had created a legal document that set forth your wishes, so you could direct who would be you Executor and where your assets would go. It does not avoid Probate Court, it avoids the laws of Descent, Distribution and Advancement.[10]

These laws are designed so that if someone passes away without a Last Will & Testament, the law will direct where those assets will go. The law says that if your estate is less than $250,000, it will go to a surviving spouse, but if your estate is larger, there are rules that may not result in everything going to your spouse.[11] Depending on your situation, it may even be possible for your children from a prior marriage – even if you haven't seen them since the divorce - to inherit some of your assets if you do not have a Last Will & Testament.[12]

<u>Avoiding Probate Court with a Revocable Trust</u>

A Revocable Trust is a legal document that is most often used to replace a Last Will & Testament for transferring property when someone passes away. A Revocable Trust can be used by anyone who wants to avoid the Probate Court process for property that they own. Property can include real estate, mobile homes, bank accounts, cars, business interests, and many other types of assets.

There are many benefits to creating a Revocable Trust. Revocable Trusts allow immediate access to the property when the Grantor passes away so that funeral arrangements can be made, so that

[8] See NH RSA 552:3.
[9] See NH RSA 554.
[10] See NH RSA 561.
[11] See NH RSA 561:1.
[12] See NH RSA 561:1.I.(e).

mortgages and bills can be paid, and to ensure that the property and beneficiaries are protected from the property decreasing in value or being lost. Revocable Trusts avoid Probate Court so that the property and beneficiaries' information remains private. Revocable Trusts allow the Grantor to spread payments out over time to ensure that beneficiaries who have a difficult time managing money do not have large sums given to them at once. Revocable Trusts can allow the Grantor to specify that beneficiaries can only use the property for specific purposes, like college educations. Revocable Trusts can control how property are spent for beneficiaries who are under eighteen (18) years old and safeguard property for disabled beneficiaries.

The What, Why, and How of Ridge Culture Root Crop Production For Wholesale

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MX Morningstar is a diversified vegetable farm and retail business located in the upper Hudson Valley. The farm manages 50 acres of tillable land, growing 35 acres of field vegetable crops and 1 acre of high tunnel crops. The business specializes the production of root, potato, sweet potato, winter squash and radicchio production for sales to their year round retail store, distributors and other farms.

WHAT

Ridge culture is a method of producing crops on ridges or small formed hills, typically spaced between 28"-36" apart from center of ridge to center of ridge. Seeds are sown in multi-line bands, 2-4 rows of crop within each band and each band being a total width of between 2 and 6". Spacing of ridges and band width/row count are determined by the desired density (both for yield and root size desired), soil type and tractor configuration.

WHY

Our farm is primarily comprised of alluvial deposits of fine sandy loam, and though well drained and fine in texture, has a high enough clay content that during extended wet periods has a tendency to become clumpy and heavy, especially in lower portions of the farm. By forming ridges and elevating the crop we improve drainage and airflow, reducing tip rot and foliar diseases, as well as improving root shape in carrots, which produce longer, straighter roots if conditions are wet during root formation. Large root size and consistency lead to a more marketable product, as the average consumer makes root purchasing decisions based on the aesthetics of the product. Any method that can improve our quality and get us closer to industry standards opens up more sales channels. Another major goal of the system was to reduce the amount of soil that clung to the roots during mechanical harvest, which is an issue during wet fall harvest periods. Though we have not had an "apples to apples" fall harvest comparison with the droughty fall we experienced this season, the theory seems to be playing out the way we imagined.

Previously, our production system for roots was 3 single rows seeded with a Bassi ground drive seeder. Rows were spaced 18" apart on a 56" bed top with 72" tractor centers. In the ridge system, there is 1 band per ridge, 2 rows per band, each spaced 2" apart. Ridges spaced 36" apart with the same 72" tire centers. The ridge seeding is done with a 2 row Wizard vacuum seeder with a twin-line planting shoe. Our tillage, bed prep and cultivation system is much the same for most of our root crops with irrigation and herbicide differences by crop, so the example used below is for carrot production, which is our most intensive.

HOW

Field is either moldboard ploughed or disk harrowed depending on cover crop residue, followed by subsoiling with a 3 shank V-ripper, and then tilled with a Forigo stone burier. After the stone

burier, a ridge or row former is used to shape ridges. The former we use is a “Hartland” brand row former purchased it in 2017 from a used potato equipment dealer in Canada. Simply a big heavy pan style bed former creating two ridges, approximately 6” wide at the top and 12” high to the bottom of the track. Carrots are seeded with the Wizard vacuum planter at a rate of 72 seeds per foot of band, or 36 seeds per row foot. After seeding, irrigation lines are installed and Netafim Meganet sprinklers are installed and sets are run 3 times a day for approximately 3 hours per set until emergence. Just prior to emergence Homeplate organic herbicide, at a 3% dilution with Kinetic sticker spreader, is applied by backpack sprayer directly to the 6” ridge top. The per-acre rate is 100 gallons multiplied by the 6” bed top. For an acre of carrots this equates to 16.5 gallons of mix (and 4,800 steps for someone with a 3’ stride). After full emergence, the irrigation lines are removed and the first cultivation is performed using a Kult-Kress Duo and subsequent cultivations are done using a Kult-Kress ridge cultivator with a combination of shanks and hilling disks to cultivate and reform the row. Irrigation water is applied via water reel travelers, aiming for between 1-3” of rain a week depending on the stage of development. Hand weeding is still required, but greatly reduced by the uphill advantage of the cultivation system and herbicide. The 2024 fall carrot crop required 18 personnel hours of weeding for 1 acre (4 workers for 4.5 hours).
When roots reach marketable size, harvest is conducted with a Scott Viner carrot and beet harvester which places the carrots into 20 bushel bins which are stored until washing and grading. A bin dumper is used to meter the carrots into an AZS root washer, followed by an AZS brush washer which polishes the roots and allows for “pick-out” of damaged, undersized or unmarketable roots. Following grading a conveyor deposits them into a Haines brand foot pedal operated potato bagger. Roots are predominantly sold by the 25lb bag and are batch washed to order, though in our experience there is little storage quality difference between dirty and washed roots.

Our fall carrot harvest total this fall was 29,789lbs harvested from 0.92 acres, our pick-out from grading and dirt weight is estimated around 6300lbs, so 23,517lbs of marketable carrots.

A rough breakdown of labor costs would look like:

7 hours of bed preparation work
12 hours of irrigation management
6.75 hours of mechanical cultivation
18 hours of manual weed removal
41 hours of harvest
30 hours of post harvest handling
114.75 personnel hours per 23,571lbs of carrots

114.75 X $30/hr = $3442.5

Future experimentation and improvements will be: Growing other root crops on a ridge that generally perform well within our old system, decreasing carrot density to further improve root consistency and size, potentially building a sprayer specifically for herbicide, and looking for cultivation tools specifically designed to be used in vegetable ridge culture.

Bringing Sweet Potato Variety Recommendations Up to Date:
New Options to Consider for the North

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Over a decade ago, we evaluated several commercial varieties of sweet potato and developed recommendations for growers in the northeast. Since that time, many new varieties have been released by Louisiana State University (LSU) and North Carolina State University (NSCU), including: Bellevue (LSU 2015), Bonita and Bayou Belle (LSU 2011), Orleans (LSU 2012), Evangeline and Murasaki (LSU 2008), Monaco, Purple Majesty, and Purple Splendor (NCSU 2021), and Vermillion (LSU 2021). Further, there are several breeding lines in the variety development pipeline that may be released soon. Our goal was to compare the newest varieties and breeding lines with standard recommended varieties (Covington and Beauregard). Results are presented here for 10 commercially available varieties.

Sites & Materials: Sweet potato cultivars were planted in three locations (Durham NH, Unity ME, and North Haverhill NH) in 2023. Slips were received during the week of 5 June and planted on 7-9 June. The Durham site was certified organic, and the Durham and Unity sites used organic practices. All commercial varieties were obtained as organic slips from Sprout Mountain Farms (Kingsport, TN) and Jones Family Farms (Bailey, NC).

Planting: Slips were planted in single rows on 30-inch-wide beds covered with black plastic mulch. Drip irrigation was used in Durham and Unity, but not in N. Haverhill. Fertility was applied pre-plant: 75 lbs/acre of N and 200 lbs/acre of K_2O. Plants were spaced 9 inches apart in each row, and each plot had 25 plants/plot. We used a randomized complete block design with four replicates/blocks.

Harvest: Roots were harvested by hand-digging after hand-cutting vines. Harvest took place between 25 Sept and 4 Oct, 2024. Roots were sorted into the following categories: marketable (root diameter at least 1.5 inch with no major defects that would reduce storage life), cull (roots of any size that exhibited wounds, breakage, or severe cracking that would reduce storage life), and undersized (roots with diameter less than 1.5 inches that were not cull). The marketable category in this modified rating system corresponds with the U.S. standard No. 1 and No. 2 categories (USDA, 2005).

Postharvest quality evaluation: After digging, roots were placed in bushel boxes and cured in a greenhouse kept above 60F for one week prior to moving to long-term storage. Roots were stored long term in a chamber maintained at 60F. Seven weeks after harvest, roots were sampled for brix and dry matter measurements and were prepared for taste tests. Taste tests were conducted by our lab members and their families, who evaluated all varieties after preparing them identically (baked or roasted) with each variety coded with a distinct letter.

Results: See yield (Table 1) and quality ratings (Table 2), below.

Table 1. Marketable yield (bushels per acre) for sweet potato cultivars grown in three locations in 2023. Within a site, cultivars followed by the same letter are not significantly different.

Durham NH			Unity ME			N Haverhill NH		
Bayou Belle	A	563	Bayou Belle	BC	120	Bayou Belle	CDE	216
Beauregard	AB	524	Beauregard	A	294	Beauregard	AB	381
Bellevue	ABC	512				Bellevue	CDE	225
Bonita	ABC	466				Bonita	BCD	239
Covington	ABC	439	Covington	AB	199	Covington	DE	145
Evangeline	BC	317				Evangeline	CDE	221
Murasaki	C	312	Murasaki	C	30	Murasaki	DE	108
Orleans	A	558	Orleans	A	261	Orleans	ABC	357
Purple Majesty	C	301	P Majesty	C	74	P Majesty	E	90
Purple Splendor	ABC	495				P Splendor	A	388

Table 2. Mean flesh color, flavor, texture, and overall ratings by Sideman lab members and their families for sweet potato cultivars grown in Durham NH in 2023. Flavor, brix (Bx) and percent dry matter (%DM) were evaluated in mid-November, seven weeks after harvest. Ratings ranged from 1 = "dislike a lot" to 5 = "like a lot". When differences were statistically significant, Tukey's test was used to compare cultivars; those followed by the same letter were not significantly different.

Number of tasters	Variety	Flesh Color	Flavor	Texture	Overall	% DM	°Bx
17	Bayou Belle	4.19 AB	3.81 AB	4.06	3.71	21% CD	8.8 BC
17	Beauregard	4.31 AB	3.13 AB	3.56	3.24	21% CD	7.2 E
16	Bellevue	4.20 AB	2.73 B	3.13	3.00	17% E	7.5 DE
18	Bonita	2.71 CD	3.88 AB	3.71	3.67	21% CD	7.0 E
15	Covington	4.43 AB	4.29 A	4.21	4.40	21% BC	9.3 AB
16	Evangeline	3.67 ABCD	2.93 AB	3.27	3.19	22% BC	8.6 BCD
18	Murasaki	2.53 D	4.00 AB	3.35	3.67	30% A	10.3 A
18	Orleans	3.82 ABC	3.53 AB	3.88	3.56	19% DE	7.4 E
17	Purple Majesty	4.69 A	3.38 AB	3.44	3.65	23% BC	8.2 CDE
19	Purple Splendor	4.56 A	3.61 AB	3.89	3.67	25% BC	8.2 CDE
	p-value	*<.0001*	*0.0193*	*0.2446*	*0.219*	*<.0001*	*<.0001*

Conclusions:

- The two standard orange-flesh cultivars we currently recommend based on previous work, Beauregard and Covington, performed well. Beauregard was among the highest yielding cultivars in all three sites. Covington produced high yields in two sites, but produced only moderate yields in North Haverhill. Covington had the best flavor ratings and highest brix values of the orange cultivars.

- Several newer orange-fleshed cultivars produced high yields across all three sites. This includes Orleans, Bayou Belle, Bellevue, and Evangeline. From a flavor perspective, Bellevue was the only cultivar that had a significantly lower flavor rating than Covington – all others were not significantly different.

- Several cultivars with alternative flesh colors performed well. Bonita is white-skinned and white-fleshed, and produced high yields. Murasaki has very high brix and dry matter, with excellent eating quality – but only produced moderate yields. Of the two purple-fleshed cultivars we looked at, Purple Splendor produced higher yields than Purple Majesty – yields that were comparable to several of the orange-fleshed cultivars.

- While color preferences did exist, overall ratings by tasters were not significantly different between varieties, and all were well-liked.

- Ultimately, commercial growers of sweet potato have lots of choice, including many new varieties and new colors to choose from.

Additional work will continue in 2024 and we will update this report as more results become available. With any questions, please contact becky.sideman@unh.edu or at 603-862-3203. You can follow the Sideman Lab's work on Instagram @unh_sidemanlab.

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Towards an Integrated Management Strategy for Diseases of Carrot

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Background. There are several diseases affecting carrot in the Northeastern United States, including those caused by fungi, bacteria, and nematodes. Foliar diseases can collectively affect the quality and quantity of the foliage. Significant foliar disease makes carrots difficult to harvest as the tops become weak and break-off. Root diseases affect quality and suitability for sale leading to substantial reductions in yields. We will review the predominant foliar and root diseases affecting carrots in our region and integrated management strategies to reduce crop loss.

Foliar diseases. There are two fungal diseases affecting carrot foliage: (1) Alternaria leaf blight caused by *Alternaria dauci*, and (2) Cercospora leaf blight caused by *Cercospora carotae.* Foliar disease may also be caused by the bacterial pathogen, *Xanothomonas campestris* pv. *carotae*. In NY surveys conducted over the last 3 years, Alternaria leaf blight was the most common foliar disease. Symptoms of Alternaria leaf blight generally first appear as small brown lesions on the margins and tips of the leaflets (Fig. 1). The lesions are usually irregular in shape and size and dark brown to black in color. The lesions rapidly spread under favorable conditions (high relative humidity and leaf wetness) and affected foliage appears 'burnt' as leaflets shrivel. Large black lesions also develop on the petioles and may girdle and kill the leaves. Symptoms of Alternaria and Cercospora leaf blights are hard to differentiate in the field without a microscope, but Alternaria leaf blight tends to be more prevalent on the lower, older leaves at the end of the season, while Cercospora leaf blight is more prevalent on the younger leaves in the middle of the season. Symptoms of bacterial leaf blight primarily occur on the leaf margins as small, angular spots which expand and turn brown/black with a distinct yellow halo. Leaflets affected by bacterial blight become distorted and curled and symptoms are often associated with a yellow-brown ooze on the petioles.

Fig. 1. Alternaria leaf blight of carrots causing defoliation (left) and symptoms on the leaflets (right).

Root diseases. There are many diseases affecting carrot roots caused by soilborne pathogens. These include:

Bacterial soft rot caused by the bacterium, *Pectobacterium carotovorum* subsp. *carotovorum*. This disease usually occurs in storage after wounding but may also cause root disease in the field when soil is wet. Symptoms of bacterial soft rot are distinctive and begin as water-soaked lesions that quickly become mushy in the inner root core, while often the outer core remains intact (Fig. 2).

Fig. 2. Bacterial soft rot of a carrot root. Note the mushy appearance of the inner root tissue but the outer root tissue remains intact.

Root-knot nematode (*Meloidogyne hapla*) causes galls or thickened areas on carrot roots (Fig. 3). Roots may also be forked, 'hairy', and 'stubby'. Typical aboveground symptoms of damage include poor growth, stunting and premature leaf death that often occurs in patches.

Fig. 3. Symptoms of root-knot nematode affecting carrot.

Root rot of carrots may be caused by a broad range of fungi including *Rhizoctonia carotae, Pythium* spp., *Thielaviopsis basicola,* and *Rhexocercosporidium carotae*. Root rot may be visible in the field at harvest but also may develop as a post-harvest decay in storage. Root rots can be hard to distinguish by symptoms alone, and diseased samples should be sent to a diagnostic lab for identification to underpin an effective management plan.

Fig 4. Carrot root rot symptoms caused by the fungus, *Rhexocercosporidium carotae* from a field in northern NY.

Other common root diseases affecting carrots include:

- White mold caused by the fungus, *Sclerotinia sclerotiorum*; and
- Common scab, caused by the bacteria, *Streptomyces* spp.

Leaf Spots, Crazy Roots and Cool Colors: Developments in beet breeding for disease resistance

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Beets are growing in popularity, thanks to the use of roasting vegetables, the ease and convenience of sheet pan dinners, and their beneficial effects on endurance during sports and exercise. As a result, we have seen beet seed sales increase by 20 – 30% over the past few years.

Beets are relatively easy to grow but can still suffer from leaf diseases that can suppress total yield. Also, bunches of beets with healthy tops look much better than beets with diseased tops on your farm market display.

Leaf Diseases

The first leaf disease to appear in the spring is Bacterial Leaf Spot. The disease thrives in cool and wet conditions, and mostly affects seedlings and young plants. As the weather warms up and conditions become drier the second disease, Cercospora Leaf Spot, appears. Cercospora often becomes the dominant disease when the rows close in. Toward the end of the season, we can see Phoma Leaf Spot, which tends to affect the older (weaker) leaves when late season temperatures begin to drop and we get more dews.

Beet varieties with good vigor tend to be able to withstand a certain amount of disease pressure. Vigorous roots and vigorous tops help the beet seedling establishment and allow the variety to compete with weeds. Vigorous varieties also produce enough leaves to replace any leaves that have been affected by leaf diseases to keep them growing.

Our breeding program focuses on breeding beets with better resistance to Cercospora, and better overall vigor and healthiness. Some varieties that stand out are Bohan, Manolo and Irazu.

Rhizomania

Rhizomania is a disease that is caused by a virus. This virus is transmitted by a soil borne fungus. The disease causes the beets to make many adventitious roots, resulting in a “beard” or Crazy Roots. The interior of infected beets has a strange structure with a twisted zoning of white and red coloring.

Rhizomania is prevalent in sugar beet production in the Western States and Western provinces of Canada, and the disease is moving eastward and can be found in Michigan and Ontario, with some scattered reports from Western New York.
Fortunately, breeding for resistance to Rhizomania is relatively straightforward. The resistance is already bred into most sugar beet varieties and is now being incorporated into table beets as well.

The early varieties with Rhizomania varieties in the Bejo program included Manzu and Palau (good resistance, but not quite the best quality yet) and are now being followed by Bazzu, Rhizu and Irazu.

Colored Beets
In addition to red, we also have yellow, white and striped beets. The newest introduction is a hybrid yellow beet, Amarelly. The hybrid yellow beet is smooth (not lumpy) and has a nice and smooth interior (no blackening or hollow heart).

The white beet is called Avalanche. This is a very sweet beet, with very clean and sweet-tasting tops.

Our striped beet is Anello. This selection from Bejo maintains good interior color and does not fade to white in the heat of summer.

It is interesting to note that these colored beets have very healthy tops (healthier than most red beets). Something to consider for customers who like beet greens!

Beets: Rooted in Success
Here is a link to some interesting presentations on beets from the Beet Symposium during the 2024 Bejo Open Days in Holland: **https://www.bejo.com/bejos-symposium-rooted-success**
The presentations cover topics on beet breeding, production of red beets, Cultivation & storage, and Marketing & health.

Poster #2401. Exploring Kiwiberry Dormancy and Novel Frost Protection Methods

Zoe Robinson
Presenting Author

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Abstract:
Kiwiberry (*Actinidia arguta* (Siebold et Zucc.) Planch), a small, hairless relative of the kiwifruit, *Actinidia deliciosa* (Strik 2005; Ferguson and Huang 2007) is a promising novel niche crop for New England because of its adaptability, flavor, nutrient profile, and marketable characteristics (Cossio, Debersaques, and Latocha 2015). Although kiwiberries have been successfully grown in New England, there are research gaps on several horticultural traits and management practices, including chilling requirement and frost protection (Hastings and Hale 2021). Our study sought to characterize the chilling requirement of the 'Geneva 3' kiwiberry variety, and to explore the effect of an ecodormancy application of gibberellic acid (GA_3) on budbreak delay of 'Meader Female' and 'Ananasnaya' kiwiberry to reduce spring frost risk. Experiments were conducted at UNH Woodman Farm, Durham, NH.

Chill requirement of 'Geneva 3' Kiwiberry
Starting August 1, 2023, hourly average temperatures from the Woodman Farm weather station were used to calculate chill portion accumulation. Treatments were various amounts of chill applied to the vines, measured in chill portions (CP), under natural vineyard conditions. At 25, 30, 35, 40, 45, 50, 60, and 80 chill portions, three 12-bud portions from six 'Geneva 3' vines were removed from each vine and forced at room temperature under continuous light for four weeks, then percent budburst was calculated. Chill requirement was considered fulfilled at 30% budburst. Low budburst percentages (<15%) were observed at 35 and 40 CP. 45 CP laterals exceeded 40% budburst, signaling fulfillment of chill requirement for 'Geneva 3'. Budbreak for all subsequent treatments also exceeded 30%. This suggests the chill requirement for 'Geneva 3' is between 40-45 CP.

Effect of ecodormancy application of GA_3 on spring budbreak
Four blocks of two 'Ananasnaya' and two 'Meader Female' vines were used (16 vines total). One vine of each variety per block was designated to receive GA_3. Two laterals on the non-GA_3 vine were marked as controls. Four treatments were applied to two laterals on each GA_3 vine: 0 ppm (in-vine control), 10 ppm, 100 ppm, and 1000 ppm on February 10, 2024. Starting early April, laterals were monitored for budbreak. Date of budbreak was recorded at 50% budbreak. There was no significant difference between the in-vine control laterals and the control vine. There was also no significant difference in budbreak date between GA_3 treatments. We therefore conclude that late-ecodormancy application of GA_3 is not effective at delaying spring budbreak in 'Ananasnaya' and 'Meader Female' kiwiberry.

Poster #2402. Effect of gibberellic acid (GA3) and cluster thinning on fruit quality, cluster quality and yield in seedless table grape cultivars

Radhika Rani
Presenting Author

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Rebecca Sideman	Professor; Department Chair, University of New Hampshire, Durham, NH
Ella Lukacz	Undergraduate Student, University of New Hampshire, Durham, NH
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Abstract:
The objective of our study was to evaluate the effect of 1) gibberellic acid (GA_3), a plant growth regulator on cluster quality of 'Concord Seedless' and 2) cluster thinning on cluster quality, yield and fruit composition of seedless table grape cultivar 'Mars' and 'Canadice' grown in two training systems, Vertical Shoot Positioning (VSP) and Munson (M). Previous work studying these practices on *V. vinifera* table grapes has shown positive outcomes in terms of fruit quality and composition, but much less information is available for interspecific (*V. labrusca*, *V. vinifera*, and others) seedless table grape cultivars.

Separate experiments were conducted at Woodman Horticultural Research farm, Durham NH. For experiment 1, using the cultivar 'Concord Seedless', we tested the effect of different concentrations of GA_3 applied at two development stages: pre-bloom (0, 21, 42 and 63 mg/L active ingredient of GA_3) and post-bloom (0 and 50 mg/L active ingredient of GA_3). We hypothesized that pre-bloom application of GA_3 would decrease cluster compactness and would have a positive effect on berry weight and cluster weight, and that post bloom application of GA_3 would increase cluster weight. A split plot design with four blocks was used, with training system as main plot and GA_3 treatments as subplot. Cluster weight, number of shot berries, cluster curling, and cluster thinning were measured.

For experiment 2, we tested the effect of two thinning treatments (Light thinning and Heavy thinning) against control on the cultivars 'Canadice' and 'Mars'. For Control, no clusters were removed from the vines. For light thinning, 2 clusters were left per shoot, and 1 cluster was left per shoot for heavy thinning. We hypothesized that cluster thinning would reduce total yields while increasing fruit and cluster quality. A split-split plot design with four blocks was used, with training system as main plot, cultivars as sub-plot, and cluster thinning treatments as sub-sub plot. Total yield, cluster weight, berry weight and total soluble solids (TSS) were measured.

Results from experiment 1 showed that GA_3 (50 mg/L a.i) applied post bloom increased cluster weight and reduced the number of shot berries as compared to other GA_3 treatments and the untreated control. Results from experiment 2 showed that cluster thinning did not affect total yield, cluster weight or berry weight, but thinning did increase total soluble solids (TSS) measured at harvest.

Poster #2403. Evaluating Yield and Quality of Heat-Tolerant Broccoli Varieties for Rhode Island Farmers

Calla Pederson
Presenting Author

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Abstract:
In the United States, broccoli is a popular vegetable, important for its nutrition and economic contributions alike. However, its future production is at risk as broccoli prefers cooler climates, with an optimal temperature range of 15 - 23˚C (59 - 73˚F) for growth, especially in the weeks leading up to harvest. Temperatures above this threshold lead to failure to develop, damage, and unmarketability. There is additional desire for heat-tolerant broccoli development to circumvent wet, cool conditions that encourage disease development. We conducted a variety trial of 12 heat-tolerant broccoli cultivars using a randomized block design and three staggered planting dates throughout the summer of 2024. We aimed to determine a subset of heat-tolerant broccoli varieties that perform the best, using standard measures of quality and yield, in Rhode Island's microclimate. This will help ensure the future of the crop to meet nutritional needs and demand of the population, as well as economic needs for farmers by preventing yield loss, especially for small-scale, diversified farms that grow and distribute on a local level. (Results still in progress)

Poster #2404. Legume Cover Crop Winter Survival and Spring Growth

Arthur Siller
Presenting Author

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Abstract:
Winter legumes are highly useful cover crops that can add substantial amounts of nitrogen and biomass to the soil when killed in the spring. Historically, few legumes have been hardy enough to survive New England winters but milder winter weather caused by climate change means that additional species may be suitable throughout the region. Northeastern states are collaborating to explore the winter survival and spring growth of three regionally-undertested legumes (crimson clover, winter pea, and balansa clover) compared to hairy vetch. In each location, the four legumes were planted as monocultures, with oats, and with cereal rye at two planting times: six and three weeks before typical first frost.

All four legumes overwintered consistently regardless of planting date. Crimson clover produced as much as 3100 lbs/acre dry matter but the quantity was highly variable between locations and planting times. Hairy vetch had lower biomass yield (up to 2000 lbs/acre) but was more consistent between planting times than crimson clover while balansa clover generally had lower yields than either crimson clover or hairy vetch. Poor seedling emergence limited the spring growth potential of winter pea.

The effects of grass companions and planting time were mixed. Growing legumes with a rye companion crop generally lowered spring legume biomass while oats also reduced legume growth relative to monoculture in Vermont. In 2023-2024, earlier planting resulted in more

legume growth in Massachusetts and Maine but later planting was better in Vermont and Pennsylvania.

These results show that crimson clover in particular may be used as a winter legume cover crop father north than was historically possible. Balansa clover has potential as well, and may in fact be more suitable for underseeding and frost seeding due to its small seed. While winter peas survived the winter well, there appear to be varietal differences in seedling vigor which can have large effects on stand quality.

Poster #2405. Insights on Agritourism among U.S. Specialty Crop Producers: Evidence from the 2024 National Agritourism Producer Survey

Jason S Entsminger
Presenting Author

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Claudia Schmidt	Assistant Professor of Marketing and Local/Regional Food Systems and State Extension Specialist, Pennsylvania State University, State College, PA

Abstract:
Agritourism is increasingly targeted as an income diversification strategy for farms, particularly among small-scale producers of specialty crops. Given the nascency of agritourism within the farm economy, relevant data is limited and often lacks nuance. In response, researchers at U.S. Land-Grant institutions have implemented a series of primary data collection efforts to improve knowledge of agritourism activities, challenges, and impacts on American farms.

This poster presents initial findings from the latest effort, the 2024 National Agritourism Producer Survey, implemented with funding from USDA NIFA. Among survey responses, 1,089 came from farms indicating they produce at least one specialty crop. This includes farms producing fruits and vegetables (83.8%); nursery, flowers, and Christmas tree (43.5%); maple (2.4%); and herbs and spices (1.1%). Specialty crop respondents came from 48 states, with notable samples from Pennsylvania (11.3%), Tennessee (7.3%), Maine (6.1%), and the Carolinas (4% each). Approximately 30% of the specialty crop producers in the sample were farms in the Northeast, and 10% were from New England states.

Data indicates that many specialty crop farms engaged in agritourism have diversified agricultural practices, including row and field crop and animal production systems and on-farm value-addition. A majority of specialty crop farms engage in on-farm sales and offer educational programming to attract and welcome visitors. Many engage in pick-your-own sales strategies, and some organize or host special events and/or offer entertainment. While most specialty crop farms initiated agritourism activities before the pandemic, approximately one-third have began engagement within the past 5 years. A plurality had 500 or fewer visits and welcomed visitors to the farm 90 or fewer days during 2023. Critically, despite a majority (50.2%) having at least $25,000 in revenue from agritourism activities, this may not translate to enhanced profitability; 71% of specialty crop producing respondents reported net income from agritourism activities in 2023 being under $25,000, including 28.7% who said their agritourism activities operated breakeven or at a loss.

In addition to descriptive information about these attributes, this poster also presents findings on a series of items from which the research team identifies key challenges from regulatory and resource perspectives and develops understanding of the tourism destination and agritourism

support environments in which agritourism operates. Through findings summarized on this poster and dialogue with researchers, NEVFC attendees will learn about critical issues facing specialty crop enterprises engaged in agritourism and consider opportunities to build the support system for these enterprises.

Poster #2406. Increasing fruit quality and yield for husk cherries (*Physalis pruinosa*) in New England

Christina Monk
Presenting Author

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Rebecca Brown	Professor, University of Rhode Island, South Kingstown, RI

Abstract:
Husk cherries are a small, sweet fruit trying to make their way into the New England market. The goal was to simulate a preferred growing environment for the husk cherries to increase yield and fruit quality in our cool climate. To recreate this warmer environment, perforated plastic was added to the beds until flowering. Actinovate and Regalia were applied to the foliage to increase the overall health and disease resistance of the plants. Midway through the trial it became apparent that the plants were infected with tobacco streak virus (TSV). This affected the results of the trial due to plant loss and stunting. Data was still collected and overall, the protected plants seemed to perform better than the unprotected plants in the presence of the virus. To conclude, although it technically appeared that the protected plants performed better than the unprotected plants, nothing is conclusive due to the effects of the virus. This project was repeated the following year using netted cages to protect the plants from thrips, to prevent infection. Regardless, TSV once again infected the crop rendering the results as, once again, inconclusive. For future projects more efficient harvesting techniques should be considered as well as checking the seed for contamination.

Poster #2407. Can over-fertilization enhance soilborne plant diseases?

AbdAlla S. Mohamed
Presenting Author

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Abstract:
It is known that over-fertilization can enhance foliar diseases by modifying the plant's innate immunity to disease through increased availability of foliar nitrogen concentrations. However, much less is known about how nitrogen fertilization may affect susceptibility and growth of soilborne pathogens. Knowledge of the relationship between fertilization, plant disease, and pathogen proliferation is an important consideration for developing recommendations for producers and, in the long term, for the dynamic application of nitrogen fertilizers within a precision agriculture framework. In this stdy, we sought to investigate nitrogen fertilizer as a predictor of pre-and post-harvest *Rhizoctonia zeae* severity and density in soil, which is a soilborne necrotrophic pathogen that causes root rot, seedling blight, seedling damping off, hypocotyl and stem rot in tomatoes, pepper, legumes, cereals, and corn, leading to significant losses in final yield. In this active experiment, 132 liters of sandy-loam soil were collected from a cornfield in Connecticut, and dried, sieved, and analyzed for essential nutrients to establish nitrogen fertilization treatments. Sixteen cm pots will be filled three-quarters full of refined, sieved soil, and covered by a 1 cm depth layer of *R. zeae*-infested sorghum inoculum, covered by a 5 cm soil. Pots will be planted with nine susceptible, untreated, and non-GMO corn seeds (Hybrid85-variety 85H0103). Four levels of nitrogen fertilization will be applied (control, low, optimal, and high). The experiment will be arranged in a complete randomized design with four replications. The disease severity index on hypocotyls and roots will be rated on a 0-5 scale at 21 days post-inoculation. To quantify the pathogen in soil, 18 candidate primer pairs were synthesized and will be evaluated for amplification using DNA from *R. zeae* before the final ddPCR amplification. Finally, results will be analyzed using linear regression to characterize the potential relationships between nitrogen fertilization and this soilborne plant disease.

Poster #2408. A Comprehensive Analysis of the UConn Plant Diagnostic Laboratory's Impact and Emerging Trends

Amelia Martin
Presenting Author

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Abstract:
The University of Connecticut Plant Diagnostic Laboratory (UConn PDL) is a service provided to plant professionals and homeowners. The main function of the UConn PDL is to diagnose plant problems such as diseases, insect pests, and abiotic diseases, and return that information with recommended actions and management practices. Special services like extraction and quantification of nematodes and ELISA testing are also provided. UConn PDL accepts samples year-round and averages 300 samples per year. Diagnostic labs are located across the country and are a useful resource for growers, saving time and money when disease outbreaks occur. The standard cost to submit a physical sample with the UConn PDL is $20. Since 2021, the UConn PDL has processed 939 samples, provided 2,817 client emails/calls, and provided a total of $75k in direct value to stakeholders. Including time, money, and resources saved by providing accurate management recommendations, it is estimated that the UConn PDL has provided stakeholders a direct service valued up to $3.8M since 2021, which is over $1M per year. UConn PDL collects data on each sample, such as geographical location, host plant, type of grower, symptoms, and cause. These data are used to create bi-yearly public reports that are used by researchers and growers to identify: diseases or pests that are increasingly prevalent from year to year, which crop type is being affected, and the emergence of diseases or pests in new locations. Here, we will provide an overview of the current process from collecting a sample to diagnosis and we will summarize and analyze the most recent data from 2024 to identify any emerging trends, with special emphasis on what has been identified affecting fruit and vegetable crops.

Poster #2409. Characterization of the causal agents of Alternaria leaf blight and head rot of broccoli (*Brassica oleracea* var. *italica*) grown in the eastern United States

Roy Davis
Presenting Author

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Colby LeGault	Undergraduate Researcher, University of Connecticut, Storrs, CT
Sebastian Bernal	Undergraduate Researcher, University of Connecticut, Storrs, CT
Sydney Everhart	Associate Professor, University of Connecticut, Storrs, CT

Abstract:
Broccoli production has increased precipitously in the eastern United States over the last decade. As production has increased, so has the prevalence of many major diseases of the crop, including Alternaria blight and head rot (ABHR). This is a major disease in broccoli production that is primarily caused by the *Alternaria brassicicola* in the East Coast of the United States. In conventionally managed fields, *A. brassicicola* is typically controlled using strobilurin and/or SDHI fungicides. In Connecticut, however, broccoli and other brassica crops are typically grown using organic agricultural practices, which have few chemical intervention options. In 2022 and 2023, a multistate ABHR disease survey of broccoli was conducted in Connecticut, Massachusetts, New York, Virginia, and Georgia to identify the causal agents. In this survey, *A. brassicicola* was identified in all states surveyed, while an additional species, *A. alternata*, was also identified from AHBR on broccoli in Connecticut and Virginia. Differences in pathogen species may influence disease management recommendations. Going further, we have developed and applied population genetics to analyze *A. brassicicola* from two organic and two conventionally managed fields. Results showed that fields closer together were more genetically similar, which supports the possibility of local pathogen establishment and short distance spread. This result, however, cannot be fully differentiated from seed-dissemination as a route of introduction. Collectively, these investigations provide important and novel information that is aimed at improving management recommendations for both conventional and organically managed broccoli production in the eastern US.

Poster #2410. Resistance to QoI (FRAC 11) and SDHI (FRAC 7) fungicides found in fungi causing Alternaria leaf blight and head rot of broccoli in the Eastern US

Daniel Cerritos Garcia
Presenting Author

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Abstract:
Alternaria leaf blight and head rot (ABHR) is a devastating foliar disease of broccoli and other brassica crops caused by the fungi *A. brassicicola*, *A. japonica*, *A. brassicae* and *A. alternata*. ABHR can appear at any growth stage, but as the disease progresses, lesions can appear in broccoli heads making them unmarkable. ABHR is managed using a combination of cultural practices and chemical control. For chemical control, preventive applications of Quinone outside inhibitors (QoI: FRAC 11) and succinate dehydrogenase inhibitor (SDHI: FRAC 7) are recommended to prevent spore germination and consequent disease development. Between 2015 and 2016, growers and extension agents in Georgia and Virginia start reporting failure of the QoI, Quadris (azoxystrobin) to control ABHR. Recently, anecdotal reports from extension agents suggest that there is also resistance to the SDHI fungicide, Endura (boscalid) in Georgia and New York. To investigate if resistance to these fungicides is present in these states, we conducted a multistate survey between 2021 and 2023 and collected Alternaria spp. in these states as well as Connecticut and Massachusetts. Fields in Georgia, New York and Virginia were conventionally managed whereas fields in Connecticut and Massachusetts were organically managed. In all states, A. brassicicola was the predominant species causing ABHR, but A. alternata was also identified in all states except Georgia. In vitro assays were conducted and sensitivity to technical grade azoxystrobin was compared among isolates by calculating the effective concentration at which only 50% of spores germinate (EC50). Results showed A. brassicicola was sensitive to azoxystrobin with EC50 values lower than 1 ppm. Multiple A. alternata isolates had EC50 values ranging from 10 to 100 ppm; these isolates were confirmed to possess heritable fungicide resistant after gene sequencing of the target site. The most resistant A. alternata isolates were found in Virginia. In Connecticut less than 25% of the A. alternata isolates were resistant. Preliminary data suggest that A. brassicicola is resistant to boscalid, but cross resistance within the FRAC7 group remains unknown. Based on these results, QoI remains a valuable fungicide to use to control ABHR in the Northeastern US but should be combined with other FRAC group fungicides, except boscalid where resistance has been documented.

Poster #2411. Resistance of Arugula Cultivars to the Bacterial Blight Pathogen *Pseudomonas cannabina* pv. *alisalensis*

Cameron Cedeno
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Abstract:
Arugula and, more broadly, brassica leafy greens are profitable components of mixed vegetable operations throughout the Northeast U.S. and contribute to the overall financial sustainability of these farms. However, the extent of arugula production and leafy greens in mixed vegetable operations is unknown for most states in the region. Consequently, there are no cultivar recommendations based on disease resistance or performance available for producers in the Northeast U.S. Bacterial blight disease of arugula and other brassica leafy greens is caused by the bacterial pathogen *Pseudomonas cannabina* pv. *alisalensis*. In recent years, a number of vegetable growers in the Northeast U.S. have reported bacterial blight outbreaks on their arugula plantings, both in field and high tunnel growing conditions. To make informed recommendations to growers, 26 commercially available cultivars of arugula were screened for resistance to *P. cannabina* pv. *alisalensis.* The 26 cultivars evaluated were distributed among three species of arugula: 14 *Diplotaxis tenuifolia* ('Aphrodite', 'Apollo', 'Ares', 'Athena', 'Bellezia', 'Dragon's Fire', 'Eros', 'Nemesis', 'Poseidon', 'Red Streaked', 'Sylvetta', 'Wild', 'Wildfire', 'Zeus'), 11 *Eruca sativa*, ('Astro', 'Balboa', 'Esmee', 'Green Brigade', 'Roquette', 'Runaway', 'Slow Bolt', 'Speedy', 'Standard', 'Surrey', 'Uber'), and 1 *Diplotaxis erucoides* ('Wasabi'). In greenhouse experiments, all *D. tenuifolia* and *D. erucoides* cultivars had low levels of or no disease. Disease severity among all *E. sativa* cultivars screened ranged from moderate to high. In a replicated field trial, all *D. tenuifolia* cultivars inoculated with the pathogen remained mostly asymptomatic, which was consistent with the greenhouse results. Like the greenhouse experiments, all *E. sativa* cultivars developed severe disease symptoms in inoculated field trials. Unlike in the greenhouse evaluations, the *D. erucoides* cultivar, 'Wasabi', had moderate disease in the inoculated field trial. Greenhouse and field experiments will be replicated in 2025 and will include PI lines from the USDA-ARS Germplasm Resources Information Network (GRIN) to identify bacterial blight resistant *E. sativa* germplasm. We will continue to share results from this

research with growers and seed industry cooperators through grower meetings, webinars, and the Northeast Arugula Team website.

Poster #2412. Elucidating variability of pathogenicity in *Sclerotinia sclerotiorum*, causal agent of disease on more than 450 plant species

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Abstract:
Sclerotinia sclerotiorum is a necrotrophic fungal pathogen that causes destructive diseases in more than 450 plant species, including many vegetable and fruit crops such as cabbage, carrots, green beans, peas, peppers, tomatoes, and a wide array of economically important plant species globally. This leads to significant yield losses in millions of dollars. Management of this pathogen and disease relies on cultural and chemical methods since few resistant plant cultivars exist. Evaluation of novel plant genotypes for resistance to *S. sclerotiorum* is performed through a combination of laboratory and field studies. Knowledge of the variability in pathogenicity in *S. sclerotiorum* is lacking, and such information would allow more rapid advancement of the identification of novel plant genotypes with the potential to combat this disease. To do this, we used 167 sets of AmpSeq primers to amplify regions with sequence variants in SSRs, SNPs, putative pathogenicity-related loci, and genes conferring fungicide resistance (*β-tubulin*, *Sdh* complex, and cytochrome b genes). The AmpSeq was applied to 178 *S. sclerotiorum* genomic DNA hierarchically sampled from diverse sources. We performed variant calling analysis using the GATK pipeline, a total of 2,313 variants. We filtered the variants based on sequence depth and quality score criteria using *the vcfR* package to give 1,072 variants. The filtered vcf will be for the variant association analysis using the Sequence Kernel Association Test approach (SKAT), a package for understanding the association between variants and phenotypic traits. Currently, we are testing the SKAT package on a subset of our dataset to fine-tune the analysis workflow. These results will be useful, especially for understanding the genetic basis of the traits of this economically important pathogen.